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ASSESSMENT OF GROUNDWATER QUALITY OF BOREWELLS WATER OF HOSPET TALUKA REGION, KARNATAKA, INDIA

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ABSTRACT

During the course of water quality studies of Hospet taluka region in Bellary district, Karnataka, 40 groundwater samples were collected and chemically analysed. The analysis revealed that the water was slightly alkaline (pH: 7.1 - 8.2), moderately hard (TH: 130 - 892 mg/L) and TDS values ranged from 240 to 1650 mg/L. The other parameters like SAR (2.7-13.5), percent sodium (10.2 - 54.0) and magnesium ratio (7.8 -21.5) were also below the desirable limits. Fluoride was most dominant ion responsible for contamination of the groundwater. Eleven water samples of the study area were prone to excess fluoride concentration (>1.2mg/L) and not suitable for drinking purpose. According to USSL diagram most of the samples falls in C_2S_1, C_2S_2, C_3S_1 and C_3S_2, which indicating its suitable nature for drinking and irrigation purposes. Based on the Piper trilinear diagram it was confirmed that the dug wells were characterized by secondary alkalinity in the study area. The presence of *E-coli* in only five dug wells, and only one dug well indicated potential dangerous facel contamination, which require immediate attention.

Key words : Piper trileaner diagram, USSL diagram, Kelley's ratio, Fluorosis.

INTRODUCTION

Groundwater is used for domestic supply, industries and agriculture in most parts of Bellary district in Karnataka, is a replenishable resource and has inherent advantages over surface water. There has been a tremendous increase in the demand for fresh water due to growth in population. Among the various sources of water, groundwater is said to be the safest water for drinking and domestic purposes. Nevertheless, several factors, like discharge of agricultural, domestic and industrial wastes, land use practices, geological formation, rainfall patterns and infiltration rate are reported to affect the quality of ground water in an area[1]. As groundwater moves along flow lines from recharge to discharge areas, its chemistry is altered by the effect of a variety of geochemical processes[2]. In Karnataka, there is no significant work on water quality except by Jayanthi[3], Ayed[4] and Jayalakshmi Devi et al.[5] In view of the above, it is clear that water quality assessment studies in Karnataka especially in Bellary district is inadequate. Therefore, the present study has been undertaken to assess the water quality of Hospet taluk in Karnataka.

Hospet taluk is one of the major talukas of Bellary district. It lies between $14^0\ 58^1$ to $15^0\ 28^1$ N latitude and $76^0\ 18^1$ to $76^0\ 47^1$ E longitude. It covers an area about 934 sq.km. The taluk has a population of about 3,99,402. The average annual rain fall of the study area is 593.8 mm. The average annual maximum temperature is 40^0C and minimum is 27^0C[6].The study area is covered by granodiorite, granite and metabasalt. The major portion of the taluk comprises of granodiorite and granite associated with iron and manganese ore bands. They almost standout in the form of serial hillocks and are being commercially exploited. The rock formations are joined and are traversed by doleritic Dykes. Weathering in hard rocks

is limited to 5 meters from ground level where as in schist and phyllite extends upto 20 meters. Secondary porosity weathered zone, joints fresh hard rock, provide room for groundwater storage.

EXPERIMENTAL

The present study provides a detailed description of the chemical criteria of groundwater. Forty representative samples were collected during post monsoon, 2007 and analyzed for calcium, magnesium, sodium, potassium, iron, zinc, manganese, chloride, carbonate, bicarbonate, fluoride, sulphate, nitrate, total hardness (TH), total alkalinity (TA), total dissolved solids (TDS), pH, electrical conductance (EC), turbidity and coliform bacteria. Further the sodium adsorption ratio (SAR), Kelleys ratio, soluble sodium percentage (SSP), corrosivity ratio (CR), percent sodium and magnesium hazards were calculated. The techniques and methods followed for collection, preservation, analysis and interpretation are those given by Rainwater and Thatcher,[7] Brown et al.,[8] ICMR [9], Hem[10] and APHA[11]. The chemical quality data are shown in Table-1. Various methods and graphs were used to study and interpret the water analysis data.

RESULTS AND DISCUSSION

Hydrogeochemistry

The results obtained from the analysis of water samples from different villages of Bellary taluk are shown in Table-1. Standard methods[11] have been employed in the analysis of the water samples. A comparison of the physico-chemical groundwater samples have been made with WHO (1988),[12] and ISI (1991)[13] drinking water standards. Table -2 shows the different types of water in the study area according to hydrochemistry classification. From Table-1 the following observations were made for different parameters: The pH values of groundwater varied from 7.1 to 8.2 indicating slightly alkaline nature. Groundwaters with pH value of about 10 are exceptional and may reflect contamination by strong base such as NaOH and $Ca(OH)_2$[14]. The range of desirable pH of water prescribed for drinking purpose by ISI (1991)[13] and WHO (1988)[12] is 6.5 to 8.5. The analyzed groundwater samples are within the permissible limits. There is no much distinct variation of pH in the different wells selected for the present study, indicating that the groundwater is tapping from aquifers of a single formation. The slight alkaline nature of groundwater may be due to the presence of fine aquifer sediments mixed with clay and mud, which are unable to flush off the salts during the monsoon rain and hence retained longer on other seasons.

It is well known that electrical conductance is a good measure of dissolved solids and excessive presence of sodium in water is not only unsafe for irrigation but also makes the soil uncultivatable.[15,16]. In the present investigation the electrical conductivity of the samples varies from 400 to 3500 μ mhos/cm This is within the permissible limit for 36 samples as per WHO standards. However, the higher values of EC (>2000 μ mhos/cm)
for 4 samples may be due to the long residence time and factors of lithology of water bodies[17].

Total Dissolved Solids (TDS) indicate the nature of water quality for salinity. The water samples in the study area fall in the range of 240 to 1650 mg/L. Out of 40 samples collected, 12 samples fall into the 'Fresh Water' category while 16 samples fall into the 'Brakish Water' category and 12 samples are moderately saline.Waters can be classified based on the concentration of TDS [9,15,17] as given below-

Up to 500 mg/L	Desirable for drinking
Up to 1000 mg/L	Permissible for drinking
Up to 2000 mg/L	Useful for irrigation
Above 3000 mg/L	Not useful for drinking and irrigation

Based on the above classification only 70% of the samples in the study area will come under desirable and permissible for drinking .

Total hardness is due to the presence of divalent cations of which Ca and Mg are the most abundant in groundwater. The waters of the study area are classified according to hardness as suggested by Hem.[10] In the present study, total hardness of water samples ranged from 130 to 892 mg/L. This indicates that, out

of 40 samples, only 14 samples have total hardness content within ISI permissible limit (300 mg/L) while 20 samples have excessive limit (600 mg/L) and 6 samples fall into the very hard category.

Most of the groundwaters contain substantial amounts of dissolved carbon dioxide, bicarbonates and hydroxides. These constituents are the results of dissolution of minerals in the soil and atmosphere.[18] In the present study, alkalinity ranges between 210 to 491 mg/L. The high amount of alkalinity in the study area samples may be due to the presence of country rocks.

Chloride occurs in all natural waters in widely varying concentrations. The origin of chloride in surface and groundwater may be from diverse sources such as weathering and leaching of sedimentary rocks and soils, domestic and industrial waste discharge, etc. Excessive chloride in potable water is not particularly harmful and the criteria set for this anion are based primarily on palatability and its potentially high corrosiveness.[19] Chloride in excess (>250 mg/L) imparts a salty taste to water and people who are not accustomed to high chlorides may be subjected to laxative effects. The chloride content in the study area ranged between 11.0 and 248.0 mg/L. The WHO and ISI permissible limit of chloride for drinking water is 200 and 250 mg/L respectively. The chloride value of water

samples studied is well within the permissible limit of WHO and ISI for all the samples of study area.

High concentration of fluoride, often significantly above 1.5 mg/L constitute a severe problem in large parts of Karnataka.[20,21] Teotia et al[22], found variations in fluoride concentrations with depth in groundwater from two Indian villages affected by fluorosis. From the study it is clearly shows increasing fluoride concentrations with depth are due to increased chemical reaction with increasing groundwater residence time. Long term use of groundwater for drinking has resulted in the onset of wide spread fluorosis symptoms, from mild forms of dental fluorosis to crippling skeletal fluorosis. High fluoride concentrations in the groundwater of study area correlate positively with alkalinity (bicarbonate concentration), pH, and sodium, are present in groundwaters with low concentrations. The concentration of fluoride in the study area varies from 0.20 to 2.00 mg/L .The fluoride value of the water samples studied is well within the permissible limit of ISI for 29 samples, where as 11 samples have high value of fluoride (>1.2 mg/L) and not safe for drinking purpose.

The WHO health-based guideline value for nitrate in drinking water is 45 mg/L. The concentration of nitrate in the present water samples varies from 3.0 to 78.0 mg/L. The determination of nitrate is important particularly in drinking water as its presence above 50 mg/L has adverse effects on health. When water with high nitrogen concentration is used for drinking, it causes diseases like *methaemoglobinaenia.* Few data is available for concentrations of nitrate in groundwater from Karnataka. Manjappa et al.,[23] quoted values between 0.08 mg/L and 308 mg/L for groundwaters from Davanagere taluk in Karnataka. The presence of nitrate in water is due to domestic activities and agricultural run off which dissolved in rain water leaches into the wells.[24] Nitrate is basically non-toxic but when ingested with food or water, it will be reduced by bacterial action to nitrite and then to ammonia, which are toxic. In the present study, out of 40 samples collected, 38 samples are well within the permissible limit of ISI and only 2 samples have excessive limit.

Health concerns regarding sulphates in drinking water have been raised because of reports of diarrhoea with the ingestion of water with high levels of sulphates.[25] Although there is little information describing the acute toxicity of sulphates in humans and animal data suggest that sulphate salts are not very toxic[26]. In the present study,

sulphate range from 2.0 to 195.5 mg/L. According to WHO classification, 80% of the samples belong to below permissible limit, 15% of the samples belong to permissible limit and 5% of the water samples belong to out of permissible limit.

In the present study, the iron varied from 0.10 to 0.84 mg/L. The permissible limit for iron is 0.3 mg/L. The concentration of iron in 4 water samples is high whereas in the remaining samples of the study area it is well below the permissible limit. The concentration of zinc in water samples varied from 0.32 to 1.06 mg/L. The permissible limit of zinc is 5 mg/L. These results are well below the permissible limit.The manganese ranged from 0.04 to 0.09 mg/L. The permissible limit for manganese is 0.4 mg/L. The results indicated that all the samples of the study area are within the permissible limit.

I
rrigational Quality of Water

To understand the suitability of water for irrigational purposes, certain ratios of fundamental importance are described below:

Kelley's Ratio

It has been calculated for all the 40 water samples of the study area and presented in Table-2. The range of Kelley's ratio is from 0.10 to 1.19 epm. The ratio is less than unity in 38 samples indicating their suitability for irrigational uses. Sample No.22 and 25 having 1.01 and 1.19 epm respectively, are in marginal range for irrigational purpose (Table-3).

Sodium Adsorption Ratio (SAR)

Excessive sodium in waters produces the undesirable effects of changing soil properties and reducing soil permeability.[27] Hence, the assessment of sodium concentration is necessary while considering the suitability for irrigation. The degree to which irrigation water tends to exchange positive ions (cations) in the soil and cations in the irrigation water can be represented by the sodium adsorption ratio.[28] Sodium replacing adsorbed calcium and magnesium is an hazard as it causes damage to the soil structure. It becomes compact and impervious. SAR is an important parameter for the determination of the suitability of irrigation water because it is responsible for the sodium hazard.[29] The waters were classified in relation to irrigation based on the ranges of SAR values.[30] Based on Table-3, out of 40 samples, 29 samples fall into 'Excellent' category
and 11 samples fall into 'Good' category for irrigation purpose. SAR values of the water samples vary from 2.00 to 13.50 (Table-2).

Soluble Sodium Percentage (SSP)

Wilcox[15] has recommended another classification for rating irrigation water on the basis of soluble sodium percentage (SSP). The values of SSP have been determined for all the water samples and presented in (Table 2). The ratio of SSP values in the range of 16.0 to 54.7 epm. In the present study, 2 samples are 'Excellent', 28 samples are fall into 'Good' and remaining 10 samples fall into the category of 'Permissible' (Table-3).

Magnesium Hazards

Generally, calcium and magnesium maintain a state of equilibrium in most waters. In equilibrium more magnesium in waters will adversely affect crop yields. As the rocks of the study area consists of Archean granite, schists and peninsular gneisses, it is observed that most waters contain less Mg than Ca. In the present study all the samples contain Mg ratio less than 30. This would not affect the crop yield. In the present study, the values of 'Magnesium Ratio' vary from 7.77 to 21.48 epm (Table-2) in the study area samples.

Corrosivity Ratio (CR)

Corrosion is an electrolytic process that takes place on the surface of the metal, which severely attacks and corrodes away the metal surfaces. Most of the problems are associated with salinity and encrustation problems.Water samples having corrosivity ratio of less than 1 are considered to be non-corrosive, while those with values above 1 is corrosive[31]. In the present study, 11 samples are considered as corrosive, while remaining 29 samples have CR values of less than 1 (Table-2).

Graphical Methods of Representing Analysis

Piper Trilinear Diagram

Piper diagram Collins[32] first proposed a graphical method of representation of chemical analysis. The method was latter modified by Piper[33,34] based on the concentration of dominant cations and anions, and trilinear diagram was proposed to show the percentages at milli equivalents per litre of cations and anions in water samples.

This Piper diagram modified by Davis and Dewiest[35]. The trilinear diagram of Piper are very useful in bringing out chemical relationships among groundwater's in more definite terms[36]. This is useful to understand the total chemical character of water samples in terms of cation-anion pairs.

Piper[34] classified the diamond – shaped field of the trilinear diagram into 9 areas to know quickly the quality of water and they are given below:

Area-1: Alkaline earth's (Ca+Mg) exceeds alkalies (Na+K) (includes areas 5,6 and 9a).
Area-2: Alkalies exceed alkaline earth's (includes areas 7,8 and 9b).
Area-3: Weak acids ($CO_3 + HCO_3$) exceed strong acids ($SO_4 + Cl + F$) (includes areas 5, 8 and 9b).
Area-4: Strong acids exceed weak acids (includes areas 6, 7 and 9b).
Area-5: Carbonate hardness (secondary alkalinity) exceeds 50%.
Area-6: Non-carbonate hardness (secondary salinity) exceeds 50%.
Area-7: Non-carbonate alkali (primary salinity) exceeds 50%.
Area-8: Carbonate alkali (primary alkalinity) exceeds 50%.
Area-9: None of the cation and anion pairs exceed 50%.

In the present study, it is noted that most of the samples of study area fall under area-1, 2 samples fall under area-2 ; 38 samples fall under area-3 ; 4 samples fall under area-4 ; 35 samples fall under area-5 ; 5 samples from study area fall under area-9 ; and no samples fall under area-6, 7 and 8 (Figure-1).

Most of the water samples of study area exhibit higher amount of Ca and Mg ions among the cations and bicarbonates among anions. This may be due to the dissolution of carbonates of Ca and Mg. Groundwaters of the study area is characterized by temporary hardness. Concentration of Ca in groundwater samples of study area ranges from 38.5 to 297.7 mg/L. The desirable range for drinking is 75-200 ppm (Indian Standards Institution , 1991).

US Salinity Laboratory (USSL) Diagram

According to a method formulated by the US Salinity Laboratory,[28] water used for irrigation can be rated based on salinity hazards and sodium or alkali hazard. When the sodium hazards ratio and electrical conductivity of water are known, the classification of water for irrigation can be done by plotting these results on the graph. Low salinity water can be used for irrigation of most crops on most soils with little likelihood that salinity will develop. According to USSL classification (Table-2), 40 samples of groundwaters of the study area, 6 samples fall into C_2S_1 (medium salinity with low sodium), 5 samples fall into C_2S_2 (medium salinity with medium sodium), 13 samples fall into C_3S_1 (high salinity with low sodium), 12 samples fall into C_3S_2 (high salinity with medium sodium). And 4 samples fall in to C_4S_2 (high salinity with medium sodium). Out of 40 samples the 36 samples are suitable for irrigational use in almost all soil types and they facilitate good soil drainage. However, remaining 4 samples (C_3S_3, C_4S_1, C_4S_2 and C_4S_4) have medium sodium. Therefore, they may not be suitable for irrigational use (Table-2).

Percent Sodium

Sodium concentration is important in classifying the irrigation water because sodium reacts with soil to reduce its permeability. Soils containing a large proportion of sodium with carbonate as the predominant anion are termed alkali soils; those with chloride or sulphate as the predominant anion are saline soils. The role of sodium in the classification of ground water for irrigation was emphasized because of the fact that sodium reacts with soil and as a result clogging of particles takes place, there by reducing the permeability [29,37]. Percent sodium in water is a parameter computed to evaluate the suitability for irrigation[38]. The percent sodium values of the study area vary from 10.2 to 54.0. Percent sodium is plotted against electrical conductance, which is designated as a Wilcox diagram (Figure-2). From this diagram, it is clear that 11 samples fall into the category of 'Excellent to Good', 24 samples fall into the category of 'Good to Permissible', 3 samples fall into the category of 'Doubtful to Unsuitable', while 2 samples of study area fall into the category of 'Unsuitable'.

Coliforms

The bacteriological content is one of the most important aspects in drinking water quality. The most common and widespread health risk associated with drinking water is the bacterial contamination caused

either directly or indirectly by human or animal excretia. *E.coli* a typical facel coliform is selected as an indicator of facel contamination.

In the study area only five samples are found to have coliform contamination. Out of five samples only one sample (Sample No.14) has coliform contamination above 4/100 ml. The permissible limit of bacterial coliforms is 4/100ml as per WHO. Sample No.14 was
found to be contaminated with coliforms while the other samples were suitable for human consumption.

CONCLUSION

On the basis of the present study, analysis of groundwater of Hospet taluk in Karnataka state shows that only 92% of water samples have physico-chemical properties well within the permissible limits except fluoride. According to USSL, study area of 36 ground water samples fall under four types i.e., C_2S_1, C_2S_2,C_3S_1 and C_3S_2 with moderately low salinity whereas four samples were found C_4S_2 type with moderately high salinity. The value of SAR in the study area, 29 samples were of excellent type and 11 samples were good for domestic and agriculture purposes. Out of 40 samples 11 samples were showing corrosivity ratio higher than 1.These samples were corrosive. According to Piper's diagram, the study area is characterized by water having temporary hardness. The salinity and sodium hazards have been evaluated by using the Kelley's ratio. The ratio is less than unity in 38 water samples; it indicates their suitability for irrigational uses. In the area of present investigation, all the samples have less than 30% magnesium hazards indicating their suitability for irrigation. With reference to irrigational quality all the water samples are good for irrigation. The concentration of fluoride in the study area, 29 samples were well within the permissible limit. 11 samples have high value of fluoride (>1.2 mg/L) and not safe for drinking purpose. The presence of *E.coli* in only one sample of groundwater indicates potentially dangerous situation, and require immediate attention. The results also suggested that the contamination dufluoride in 11 water samples is alarming and require periodic monitoring of groundwater in the study area.

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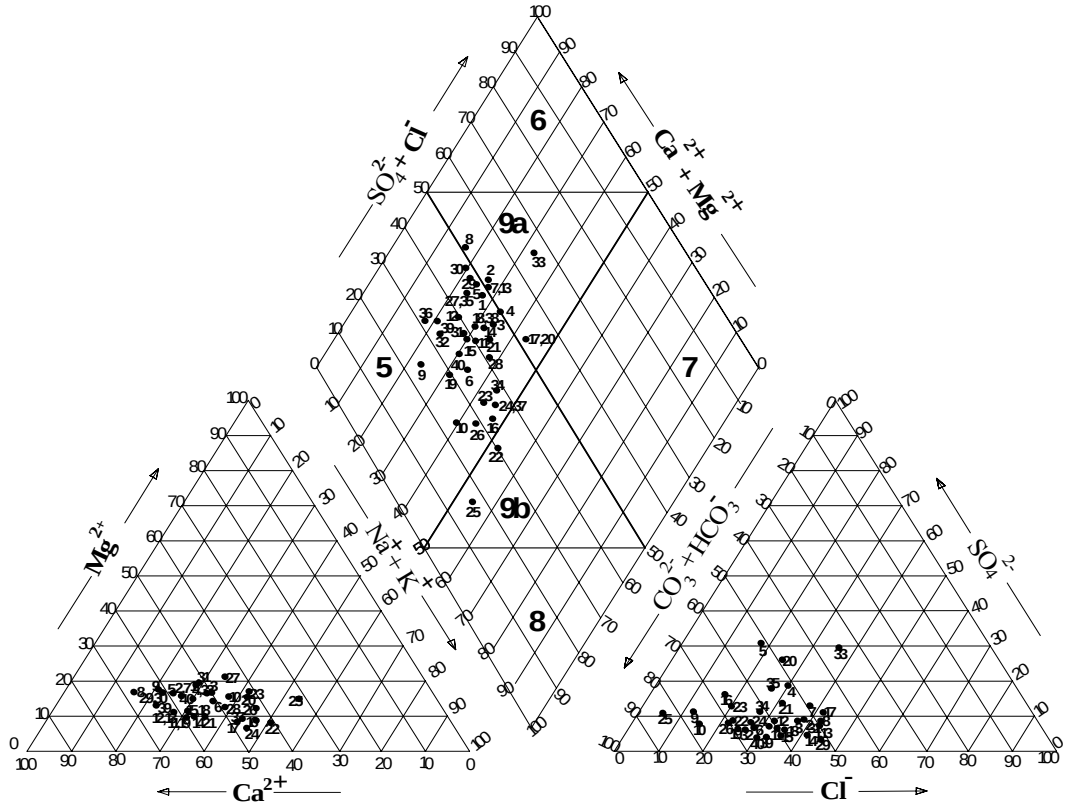

Figure 1. Piper trilinear diagram of borewell samples of Hospet taluk.

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Table- 1: Analysis of physico-chemical factors of water samples of Hospet taluk, Karnataka.

Sample No.	Turbidity (NTU)	pH	EC (μ mhos/cm)	TH (mg/l)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	CO_3^{2-} (mg/L)	HCO_3^{-} (mg/L)	F^{-} (mg/L)	SO_4^{2-} (mg/L)	NO_3^{-} (mg/L)	TA (mg/L)	TDS (mg/L)	Fe^{2+} (mg/L)	Zn^{2+} (mg/L)	Mn^{2+} (mg/L)	Coliform Bacteria (MPN/100ml)
1	1.6	7.9	1500	452	114.2	42.0	62.0	2.6	212.0	0.0	248	0.6	30.0	43.0	361	1300	0.18	0.68	0.04	
2	1.8	8.0	1900	466	125.9	38.0	58.0	1.8	190.0	0.0	252	0.2	40.0	29.0	318	1600	0.27	0.54	0.04	--
3	1.4	7.8	1500	552	127.9	40.0	80.0	5.4	199.5	14.0	271	0.8	45.0	67.0	302	1240	0.27	0.32	0.06	--
4	1.0	7.6	1300	139	101.6	32.0	64.0	1.8	47.0	10.0	68	0.4	30.0	27.0	468	620	--	0.73	0.07	--
5	1.0	7.2	630	205	186.9	48.0	72.0	8.2	39.0	14.0	99	0.6	70.0	78.0	391	340	0.09	0.54	0.08	--
6	1.0	7.3	860	185	126.0	32.0	81.0	5.4	46.0	16.0	92	0.3	10.2	35.0	402	470	0.18	0.62	0.08	--
7	1.0	7.4	900	130	133.2	41.0	62.0	2.0	57.5	10.0	61	0.2	17.5	10.0	468	590	0.09	0.55	0.04	--
8	1.2	7.4	870	132	118.8	29.0	18.0	10.4	47.0	0.0	55	0.4	10.0	46.0	491	560	--	0.46	0.04	3
9	0.2	7.2	450	223	148.1	41.0	53.0	2.2	16.5	0.0	102	0.3	15.0	18.0	352	370	0.36	0.66	0.06	--
10	1.0	7.4	400	251	79.8	26.0	67.0	2.1	27.0	0.0	126	0.8	12.0	33.0	402	310	0.18	0.52	0.06	--
11	1.1	7.8	650	335	114.2	19.8	59.0	1.0	91.5	0.0	162	1.0	16.0	22.0	416	410	0.09	0.58	0.07	--
12	1.0	8.1	1400	644	250.5	46.0	103.0	3.8	189.0	0.0	352	0.6	50.0	35.0	321	740	--	0.48	0.06	3
13	1.2	7.5	900	330	114.2	22.0	51.0	0.6	146.5	14.0	160	0.8	30.0	30.0	342	760	0.27	0.39	0.04	--
14	1.3	7.6	800	353	110.6	18.5	57.0	3.2	136.0	0.0	182	1.1	10.0	41.3	338	620	0.09	1.06	0.05	20
15	1.2	7.6	700	384	105.8	19.2	52.0	2.4	122.0	10.0	196	1.5	12.0	40.0	341	540	0.09	0.85	0.05	--
16	1.2	7.2	500	250	87.4	15.6	91.0	4.3	38.0	15.0	126	1.6	31.0	16.0	352	360	0.36	0.72	0.06	--
17	2.1	7.4	1300	422	121.0	20.8	105.0	4.4	185.0	18.0	201	0.5	48.0	42.0	321	920	0.18	0.63	0.06	--
18	2.1	7.9	1200	465	88.6	16.5	44.0	0.6	179.0	10.0	282	0.8	27.5	33.0	386	980	--	0.82	0.07	--
19	1.3	7.6	880	375	115.4	18.4	60.0	2.7	66.5	0.0	196	1.4	2.0	42.0	349	660	0.09	0.47	0.05	--
20	1.0	7.5	1000	302	117.4	40.4	108.0	8.0	82.5	0.0	160	0.7	90.0	36.0	420	700	0.18	0.44	0.09	--
21	2.5	7.8	1400	395	92.2	16.8	58.0	1.1	128.0	12.0	210	1.6	53.0	28.0	391	1060	0.09	0.54	0.07	--
22	1.0	7.7	700	395	97.8	17.0	116.0	6.2	63.0	0.0	210	1.1	28.2	17.0	332	420	0.09	0.58	0.06	--
23	1.3	7.7	700	370	84.2	33.5	86.0	1.2	60.5	8.0	198	1.7	40.0	47.0	362	480	0.18	0.51	0.04	--
24	1.4	7.8	950	410	91.4	16.0	84.0	4.4	110.5	12.0	248	1.6	28.8	39.0	351	735	0.27	0.65	0.04	--
25	1.3	7.4	1000	232	38.5	18.6	68.0	0.8	11.0	16.0	156	1.8	24.0	50.0	368	760	0.09	0.60	0.08	--
26	1.0	7.3	810	225	106.2	30.5	112.0	2.2	43.0	10.0	136	0.4	18.0	22.0	318	440	0.18	0.60	0.07	--
27	1.0	7.1	480	152	86.2	41.0	61.0	2.7	62.0	0.0	85	0.3	14.0	3.0	412	240	--	0.48	0.07	4

Table -1 *Continuied..*

Sample No.	Turbidity (NTU)	pH	EC (μ mhos/cm)	TH (mg/l)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	CO_3^{2-} (mg/L)	HCO_3^{-} (mg/L)	F^{-} (mg/L)	SO_4^{2-} (mg/L)	NO_3^{-} (mg/L)	TA (mg/L)	TDS (mg/L)	Fe^{2+} (mg/L)	Zn^{2+} (mg/L)	Mn^{2+} (mg/L)	Coliform Bacteria (MPN/100ml)
28	1.1	7.2	590	213	72.1	18.2	58.0	0.8	82.0	0.0	125	0.5	10.0	4.0	341	360	0.18	0.44	0.07	2
29	2.1	7.5	1800	365	166.1	44.2	56.0	1.4	176.5	10.0	198	0.3	21.0	5.0	369	1120	--	0.39	0.07	--
30	1.8	7.6	3200	360	180.6	56.2	59.0	1.8	168.0	0.0	212	0.9	34.0	20.0	310	1018	0.27	0.42	0.08	--
31	1.6	7.3	2200	261	159.7	61.0	84.0	8.2	85.0	10.0	152	1.3	20.0	36.0	358	1086	0.84	0.49	0.04	--
32	2.1	8.2	2400	713	187.6	58.4	73.0	0.1	162.2	10.0	391	1.3	44.0	40.0	392	1520	0.18	0.69	0.05	--
33	1.2	7.8	1800	303	97.8	32.0	61.0	0.2	140.5	11.0	211	2.0	195.0	39.0	298	625	0.09	0.61	0.05	--
34	1.4	7.8	1850	385	105.8	18.5	92.0	6.2	94.0	0.0	218	1.8	40.0	24.0	465	775	--	0.50	0.04	2
35	2.1	8.0	1800	716	244.0	70.2	84.0	3.2	151.0	10.0	316	1.0	105.0	26.0	268	1200	0.18	0.37	0.06	--
36	2.5	8.1	1300	775	297.7	89.2	87.0	6.1	134.0	0.0	342	0.6	23.0	25.2	298	980	0.46	0.92	0.06	--
37	1.1	7.2	740	140	84.2	16.8	80.0	3.2	34.5	10.0	71	1.0	11.0	35.2	478	415	--	0.74	0.07	--
38	2.1	8.0	3500	518	104.0	19.4	52.0	2.1	174.5	0.0	296	1.1	35.0	28.0	316	1400	0.18	0.61	0.07	--
39	2.2	8.2	2800	892	210.0	45.0	68.0	0.8	248.0	0.0	512	0.6	32.0	32.6	268	1650	--	0.60	0.06	--
40	1.1	8.1	1200	740	255.0	66.0	136.0	2.7	192.0	13.0	398	0.8	28.0	49.0	210	890	--	0.47	0.04	--
Min	0.2	7.1	400	130	38.5	15.6	18.0	0.1	11.0	0.0	55.0	0.2	2.0	3.0	210	240	0.09	0.32	0.04	2.0
Max	2.5	8.2	3500	892	297.7	89.2	136.0	10.4	248.0	18.0	512.0	2.0	195.0	78.0	491	1650	0.84	1.06	0.09	20
SD	0.5	0.3	743	192	56.2	17.7	22.7	2.5	64.0	6.3	102.2	0.5	33.5	15.3	61	381	0.20	0.2	0.09	6.3

Table- 2 : Irrigational specification values of groundwater samples of Hospet taluk

S No.	Sample Location	SAR	Mg Hazards	Kelley's Ratio	SSP	Percent Sodium	CR	USSL Salinity
1	Hospet Bus stand	7.0	19.0	0.39	29.2	28.0	1.3	C_3S_1
2	Hospet Govt Hospital	6.4	17.0	0.35	26.7	25.9	1.2	C_3S_1
3	Chithwadigi	8.7	15.8	0.48	33.8	31.7	1.1	C_3S_2
4	Gudi Hobalapura	3.9	16.4	0.24	32.9	32.0	1.2	C_3S_1
5	Nageena Halli	6.6	15.2	0.28	25.4	22.9	1.1	C_2S_1
6	Malpanagudi	9.2	13.1	0.51	35.3	33.1	0.7	C_3S_2
7	Kariganuru	6.6	17.4	0.35	26.9	26.0	1.4	C_3S_1
8	Papanayakana Halli	2.0	16.4	0.10	16.1	10.2	1.4	C_3S_1
9	Bhailaoddhigeri	5.5	16.8	0.28	22.6	21.7	0.4	C_2S_1
10	Dharmasagara	9.2	14.8	0.63	39.5	38.3	0.4	C_2S_2
11	Gadiganuru	7.2	10.2	0.44	30.9	30.4	0.9	C_2S_1
12	Huppara Halli	8.5	11.4	0.35	26.5	25.5	0.9	C_3S_2
13	Metri	6.2	11.7	0.37	27.5	27.2	1.4	C_3S_1
14	Devalapura	7.1	9.7	0.44	31.8	30.1	1.1	C_3S_1
15	Soogera Halli	6.6	10.7	0.42	30.3	29.0	0.9	C_2S_1
16	Hampadevana Halli	12.7	7.8	0.88	48.1	45.9	0.4	C_2S_2
17	Chikkarayaganuru	12.5	8.3	0.74	43.5	41.8	1.4	C_3S_2
18	Ramasagara	6.1	11.0	0.42	28.9	29.4	1.0	C_3S_1
19	Kamalapura Bus Stand	7.3	9.4	0.45	31.9	30.5	0.6	C_3S_1
20	Muddapura	12.2	14.7	0.68	42.4	39.4	1.3	C_3S_2
21	Belogoduhalu	7.9	10.0	0.50	35.2	34.5	0.5	C_3S_1

Table- 2 *continued..*

S No.	Sample Location	SAR	Mg Hazards	Kelley's Ratio	SSP	Percent Sodium	CR	USSL Salinity
22	Sanapura	15.3	7.8	1.01	51.6	48.9	0.6	C_2S_2
23	Itagi	11.2	16.3	0.73	42.6	42.0	0.8	C_2S_2
24	Kampli Bus Stand	11.5	8.2	0.78	45.2	42.9	0.7	C_3S_2
25	Jambunathapura	12.7	14.8	1.19	54.7	54.0	0.3	C_3S_2
26	Hampi Main Road	13.5	12.1	0.82	45.5	44.6	0.5	C_3S_2
27	Jambunathana Halli	7.6	21.5	0.48	33.4	31.9	1.2	C_2S_1
28	Kadli Halli	8.6	12.2	0.64	39.4	38.8	1.0	C_2S_1
29	Venkatapura	5.5	16.5	0.27	21.4	20.9	1.3	C_3S_1
30	Timmalapura	5.5	18.9	0.25	20.4	19.8	1.3	C_4S_2
31	Bassapura	8.0	19.5	0.38	29.5	26.8	0.8	C_3S_2
32	Chilakana Halli	6.6	18.3	0.30	22.9	22.9	0.7	C_4S_1
33	Paravana Halli	7.6	16.7	0.47	30.6	31.9	2.4	C_3S_2
34	Gollarahatti	11.7	8.3	0.70	44.1	41.3	2.2	C_3S_2
35	Nagalapura	6.7	17.5	0.26	21.7	20.9	1.0	C_3S_1
36	Danyakanakeri	6.3	18.6	0.23	19.4	18.1	0.6	C_3S_1
37	Mariyammana Halli	11.3	9.1	0.80	45.2	43.4	0.7	C_2S_2
38	Dhanapura	6.6	10.9	0.42	30.5	29.3	1.0	C_4S_2
39	Vyasana Kere	6.0	13.9	0.26	21.6	21.0	0.7	C_4S_2
40	Garaga	10.7	14.3	0.62	30.2	29.6	0.7	C_3S_2

Table -3:Frequency distribution of SAR, SSP, Mg Hazards, Kelleys ratio and USSL classification

S.No.	Water Quality Parameters	Range	Water Classes	No. of Samples
1	SAR	< 10	Excellent	29
		10 - 18	Good	11
		18 - 26	Fair	--
		> 26	Poor	--
2	SSP	< 20	Excellent	2
		20 - 40	Good	28
		40 - 60	Permissible	10
		60 - 80	Doubtful	--
		> 80	Unsuitable	--
3	Mg Hazards	< 50 %	Suitable	40
		50 - 65	Marginal	--
		> 65	Unsuitable	--
4	Kelley's Ratio	< 1	Suitable	38
		1 - 2	Marginal	2
		> 2	Unsuitable	--
5	USSL Diagram	C_2S_1	Good	6
		C_2S_2	Moderate	5
		C_3S_1	Good	13
		C_3S_2	Moderate	12
		C_4S_2	Moderate	4