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GROUNDWATER QUALITY APPRAISAL IN GUBBI TALUK, TUMAKURU DISTRICT, KARNATAKA

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ABSTRACT

The paper highlights the ground water quality of 20 selected villages in Gubbi Taluk, Karnataka. The study area represents both irrigated and dry lands where 60% of the area is overexploited and contaminated with nitrates. Ground water quality assessment is essential as erratic droughts and uneven rainfall, overexploitation of ground water for agriculture needs results in contamination of ground water in irrigated area. The samples were collected randomly and analyzed as per APHA methods. The result of water quality parameters such as pH was found within the drinking water limits ranging from 7.0 to 8.1 for all the samples. Majority of the samples, Electrical Conductivity values were found to be acceptable limits except few samples. High amount of dissolved inorganic substances or salts in ionized form causes high electrical conductivity in groundwater. Total Dissolved Solids (TDS) have crossed the permissible limit in S8 (2000 mg/L) whereas, S1, S7, S9, S11, S12, S13, S18 and S20 were found to be within the acceptable limit ranging from 372, 352, 480, 232, 316, 316, 452 and 319 mg/L respectively. Calcium content in 11 water samples were crossed the permissible limit (200 mg/L). Sulphate and Nitrate content values were observed well within the acceptable limit. Correlation matrix indicates that, majority of the parameters are positive and few were shown negative correlations, correlation ranged from highly, moderately to slightly range. It is clearly indicated that pH was negatively correlated with all the variables and was not significantly correlated with any of the studied parameters. All the variables except pH and few of alkalinity, TDS, Calcium, Magnesium and Chloride were *positively correlated. Adoption of micro irrigation system and conservation of surface water is recommended for improvement of ground water resources and quality in the study area.*

Key Words: Ground Water, Dissolved Salts, Human Health, Overexploitation, Water Quality

1. INTRODUCTION

Groundwater is an essential and basic resource for the human beings as well as the economy of the country which reflects on standards of human's daily life. The ground water resource also links with surface water flows in the form of rivers, streams, lakes, channels and play an important role in balancing the natural ecosystems as well. Groundwater occurrence, potential and movement is controlled by several factors such as topography, lithology, geological structures, depth of weathering and soil, extent of fractures, secondary factors such as porosity, slope, drainage pattern, landforms, climatic conditions and interrelationship between these factors [1].

Water demand on one hand have consumptive and productive usages has increased tremendously in recent past, and on the other hand, water supply has declined with depletion and degradation of water resources causing water distress of scarcity. Water quality is now being recognised in India as a major crisis. In most part of the country, the water supplied through groundwater is beset with problems of quality. Access to safe drinking water remains an urgent necessity, as 30% of the urban and 90% of the rural households still depend completely on untreated surface or ground water [2].

Quality of groundwater is deteriorating at a faster pace due to pollution ranging from various sources viz., septic tanks, landfill leachates, domestic sewage, mining, agricultural runoff/agricultural fields and industrial waste. Natural contamination of groundwater also depends on the geology of the area and it is rapid in hard rock areas especially in lime stone regions where extensive cavern system are below the water table. The change in quality of groundwater response is also due to variation in physical, chemical and biological environment through which it passes [3] and [4]. The problem of groundwater pollution in several parts of the country has become so acute that unless urgent steps for abatement are taken, groundwater resources may be damaged [5].

Karnataka has 13,759 million cubic meters (MCM) of utilizable groundwater for irrigation every year that can irrigate every year that can irrigate 1.38 million hectares up to one meter depth [6]. The studies of Department of Mines and Geology, Government of Karnataka found that 56 watersheds were overexploited and critically attributed to over-extraction of groundwater. These 56 watersheds fall in 34 Taluks, where Tumakuru, Kolar, Bangalore Rural, Bangalore Urban and Chitradurga districts report large number of over exploited and critical Taluks. Drastic decline in groundwater has adversely affected over 50% of villages in majority of Taluks, revealing depletion of groundwater, the major drinking water source, would affect availability and access to a large number of population [7]. The groundwater table has gone down beyond the natural rechargeable limit in recent years and its management is one of the biggest challenges for the concerned and policy makers [8]. The heavy metal concentrations in and around Tumakuru district for surface and ground water samples analyzed [9] revealed that out of 7 samples 5 samples were confirmed to use for irrigation purpose and whereas 2 samples are exceeding the standards.

In Tumakuru district, groundwater contributes to about 80% of the drinking water requirements in the rural areas, 50% of the urban water requirements and more than 50% of the irrigation requirements. Groundwater resource in Tumakuru district is widely exploited for irrigation and other domestic purposes in addition to drinking purpose, which provides water for 10 Taluks including Gubbi. One of the major problem regarding groundwater in Tumakuru District is quality (high concentration of fluorides, nitrates and chloride) and drying of wells (due to over exploitation, the water level is being lowered resulting in the drying of wells). Shallow hand pumps draw water from the topmost bearing structure, which is most liable to contamination by various natural as well as anthropogenic sources percolating in the vicinity and taking with it minerals. Over exploitation of groundwater is the major problem not only in the Taluk but also in the whole district. High concentration of nitrates (>45 mg/Lit) is observed in the western parts of Gubbi Taluk, which may be attributed to more use of fertilizers [11]. The study has taken up with a objective of assessment of physico-chemical quality of groundwater in irrigated landscapes in the study area.

2. STUDY AREA

Presence of high level chemical constituents i.e., fluoride, nitrate and chloride more than permissible limits, the groundwater quality is being deteriorated. Only a few parts in Gubbi, Turuvekere, Kunigal and Tiptur Taluks of Tumakuru district in the jurisdiction of

Hemavathi canal are getting groundwater and still, bore wells are being sunk up to deeper zones for water in some Hoblis of Gubbi Taluk.

Gubbi Taluk is one of the 10 Taluk in Tumakuru district whose total area is 1,221 sq.km. It is in the 780 m elevation, located 19 km towards west from district headquarters. It falls under eastern dry agro climatic zone and the maximum temperature recorded is 40°C (Jan-May). The geology is mainly formed from granite and gneisses and soil is of clayey type. The average annual rainfall is 540.7 mm. Gubbi taluk consists of 590 villages belongs to 34 Panchayats. The total population of the taluk is 2, 56,413 living in 54688 houses. The major sources of employment in the Taluk are agriculture, horticulture and animal husbandry, which engage almost 80% of the workforce.

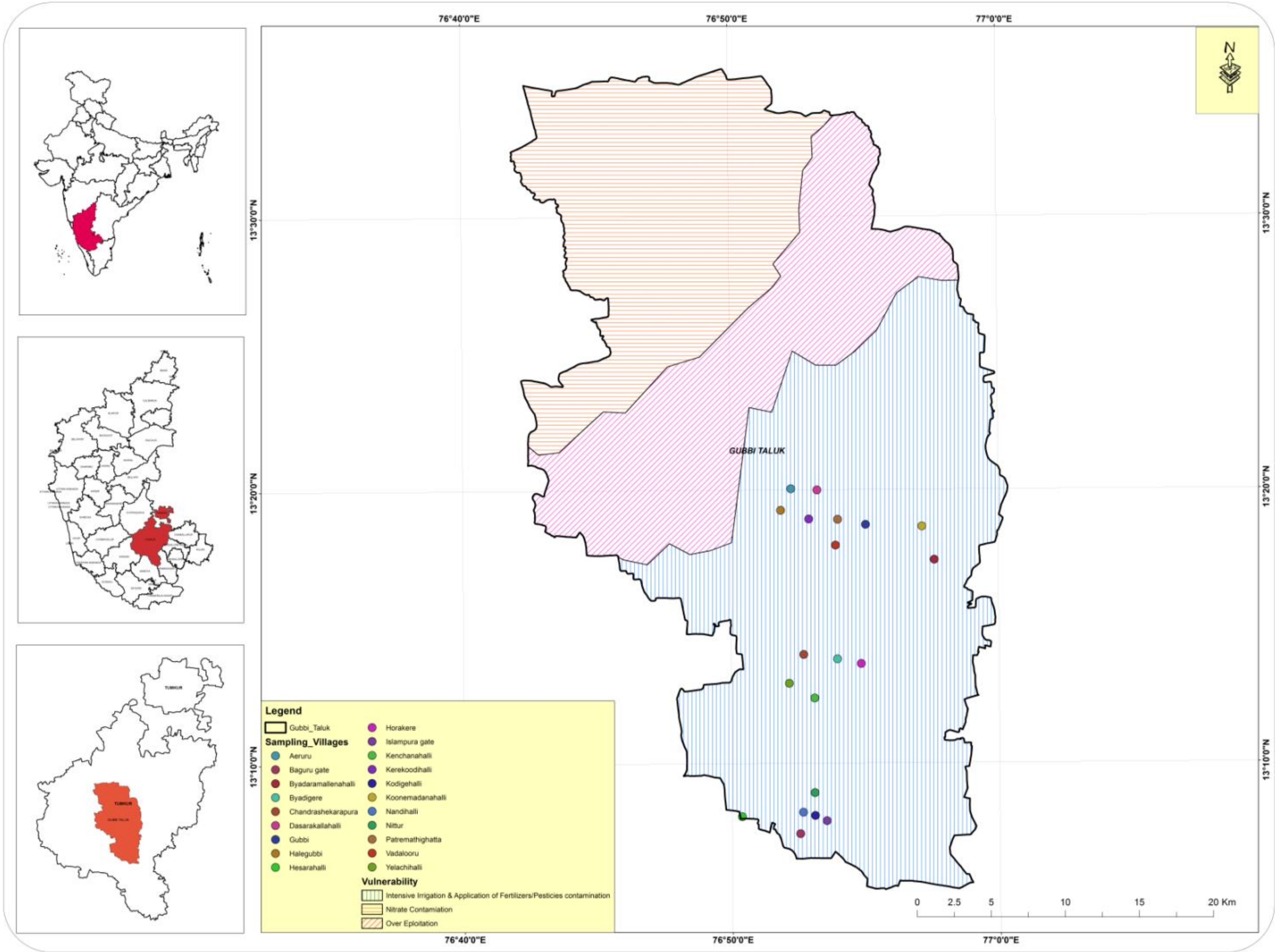

Fig -1 Study area map showing sampling ground water sampling locations

The studies on hydro chemical characteristics in the district in different seasons indicate that, based on the hydro chemical faces, the predominated water in the district is Ca-Mg-HCO_3 [10]. Digging of bore wells for drinking water and overuse of water for horticultural crops has led to fast depletion of groundwater in the district. About 20 – 30% of water being used for horticulture and farming is evaporating. It is one of the developing places where HAL (Hindustan Aeronautics Limited) Helicopter manufacturing facility is being established in the Taluk. There are no perennial rivers for irrigation in the Taluk. However, there are rivers like Shimsha and Jayamanagali are flowing only during the rainy season. As a result farmers of this region solely depend on the bore wells and tanks for irrigation. Thus, the demand for groundwater extraction for agriculture has been increasing over time leading to overexploitation of the aquifers. For irrigation there are 21314 bore wells in Gubbi Taluk to irrigate an area of 28036 ha. For drinking water supply, 2295 bore wells, 89 piped water supply schemes and 409 mini water supply schemes in the Taluk (CGWB, 2012). The depth of the groundwater level varies from 1.35 to 31.70 m which is been continuously monitored by CGWB. The study area map showing the sampling locations are given in Fig -1.

3. MATERIALS AND METHODS

Samples were collected as a representative of dry and irrigated areas where the water is provided for agricultural purposes from Hemavathy Reservoir. Out of 4 Hoblis, 5 samples were collected from each hobli. Total twenty ground water samples were collected randomly from 4 Hoblis of Gubbi Taluk in the month of March and April, 2017. Samples were collected from the hand pumps after continuously pumped for about 2-3 minutes to ensure that groundwater to be sampled was representative of aquifer without impurities. Samples were collected in polythene bottles of 1 litre capacity which were rinsed with acid before the sampling for Physico-chemical analysis. Standard methods recommended by APHA-2012 [12] were adopted for each parametric analysis of groundwater samples. The analytical methods used for analysis of water samples were given in Table-1.

Table 1. Analytical Methods and Equipment's used in the study

Sl. No	Parameter	Method	Instruments/ Equipment
1	pH	Electrometric	pH meter
2	Electrical Conductivity	Electrometric	Conductivity meter
3	Total Dissolved Solids	Electrometric	Conductivity/TDS meter
4	Alkalinity	Titration by H_2SO_4	-
5	Total Hardness	Titration by EDTA	-
6	Calcium	Titration by EDTA	-
7	Magnesium	Titration by EDTA	-
8	Chloride	Titration by $AgNO_3$	-
9	Sulphate	Turbidimetric	Turbidity meter
10	Nitrate	Ultraviolet screening	UV-VIS Spectrophotometer
11	Fluoride	SPADNS	HACH -Colorimeter
12	Phosphate	Molybdophosphoric acid	UV-VIS Spectrophotometer
13	Sodium	Flame emission	Flame photometer
14	Potassium	Flame emission	Flame photometer

4. RESULTS AND DISCUSSION

The physical observations of the samples indicated that they were colourless and odourless in nature. The analyzed parameters are briefly explained with reference to the range, variation of chemical parameters, reasons for the variation, mean value, acceptable and permissible limit as prescribed by the BIS 10500:2012 [13]. Experimental results of 20 water samples in different parts of Gubbi Taluk which shows the groundwater quality are depicted in Table-2. From these data, the following observations were made for different parameters:

4.1 pH

The pH is the determination of hydrogen ions (H+) in water. Water with pH value below 7 is acidic and water with a pH value above 7 is alkaline or basic in nature. pH of most of the natural waters falls within the range of 4 to 9. Most of the waters are acidic as it contains free acid in addition to carbonic acid and alkaline due to the presence of carbonates and bicarbonates. The desirable pH range for drinking water is 6.5 to 8.5. The pH value in the study area varied from 7.1 to 8.1 (Fig-2) where it contain no carbonates but contain bicarbonates and carbonic acid. In all the samples pH was found within the acceptable limit prescribed by BIS 10500:2012. In the correlation matrix; pH is negatively correlated to all the parameters except alkalinity, which is moderately correlated.

4.2 Electrical conductivity (EC)

Electrical conductivity is a measure of water's capacity to convey electric current, where it is directly proportional to its dissolved mineral matter content. The EC in the study area ranged from 340 – 2530 µmho/cm. EC is a decisive parameter in determining suitability of water for particular purpose. Majority of the water samples are under permissible limit whereas, few are doubtful. 55% of the samples lie within the good and permissible limit (Fig-3). In the correlation matrix; EC positively correlates with all the parameters highly, except alkalinity, fluoride, nitrate and potassium which are slightly correlated.

Table 2. Results of Physico – Chemical Parameters of Groundwater samples

Sl. no	**pH**	**EC**	**TDS**	**Alkalinity**	**TH**	**Ca^{2+}**	**Mg^{2+}**	**Cl^-**	**SO_4^{2-}**	**F^-**	**NO_3^-**	**Na^+**	**K^+**
Unit	--	mhos/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
BIS Standard	6.5-8.5	--	500-2000	200-600	200-600	75-200	30-100	250-1000	200-400	1-1.5	45	--	--
S1	7.89	610	372	88	164	100	15.55	120	0.7	0.2	0.0	68.04	1.12
S2	7.28	2320	1080	80	392	227	40.10	464	3.9	1.1	0.4	208.32	79.77
S3	7.43	2230	1280	96	496	283	51.76	408	5.9	1.2	0.3	109.92	1.40
S4	7.19	2170	1164	112	464	278	45.20	344	6.1	0.2	18.0	119.56	22.08
S5	7.24	1990	976	56	620	366	61.72	340	16.6	0.5	4.5	96.08	5.22
S6	7.60	880	548	128	320	189	31.83	56	2.5	0.1	1.6	48.58	6.84
S7	7.44	1090	352	96	208	121	21.14	52	2.2	0.6	6.7	87.11	3.86
S8	7.10	2530	1666	72	1200	738	112.27	600	14.1	0.4	8.9	115.09	10.92
S9	7.25	1260	480	120	276	157	28.91	108	1.5	0.1	0.2	86.53	7.88
S10	7.27	1460	680	160	504	272	56.38	160	2.1	0.5	0.1	105.96	8.75
S11	7.66	340	232	48	128	76	12.64	32	0.0	0.5	0.3	25.90	2.46
S12	7.34	530	316	72	152	91	14.82	56	0.0	0.5	2.2	54.96	3.95
S13	7.54	560	316	88	204	120	20.41	24	0.0	0.4	1.6	40.59	1.63
S14	7.36	1050	564	80	412	239	72.04	32	4.1	0.2	0.7	51.49	4.97
S15	7.04	1660	1132	56	500	290	51.03	308	4.3	0.3	4.5	117.04	7.26
S16	7.90	1605	801	224	490	294	47.63	280	4.0	0.3	8.4	100.10	20.90
S17	8.01	1387	691	248	430	232	48.11	260	2.5	0.8	0.0	103.31	13.05
S18	7.55	922	452	176	260	156	25.27	160	1.5	0.5	1.8	96.67	2.56
S19	8.12	1651	830	312	610	360	60.75	280	1.5	0.2	0.0	107.52	2.62
S20	7.73	654	319	168	320	192	31.10	80	0.9	0.5	0.0	38.32	2.27

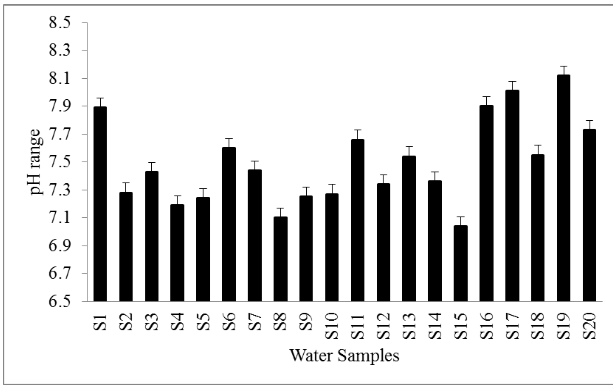

Fig (2) Variation of pH in water samples

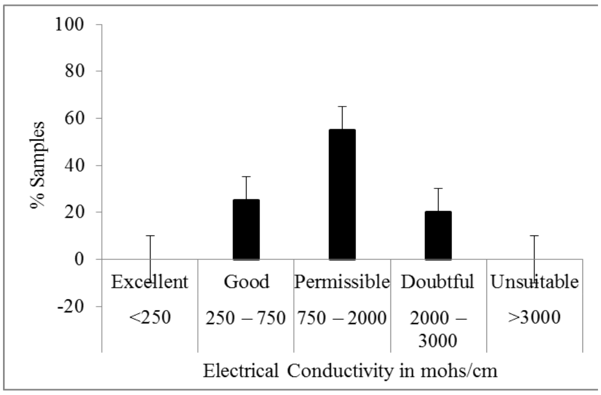

Fig (3) Variation of Electrical Conductivity

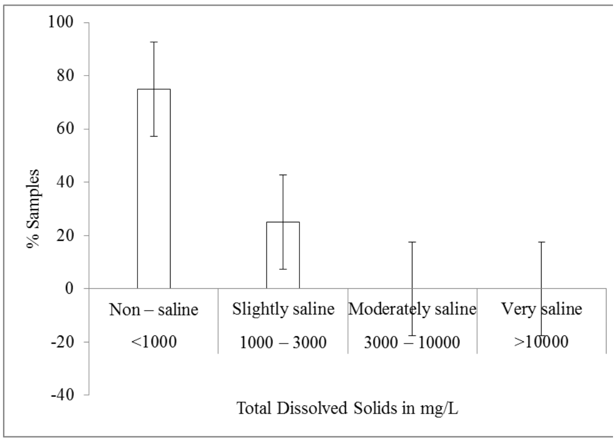

Fig (4) Variation of TDS

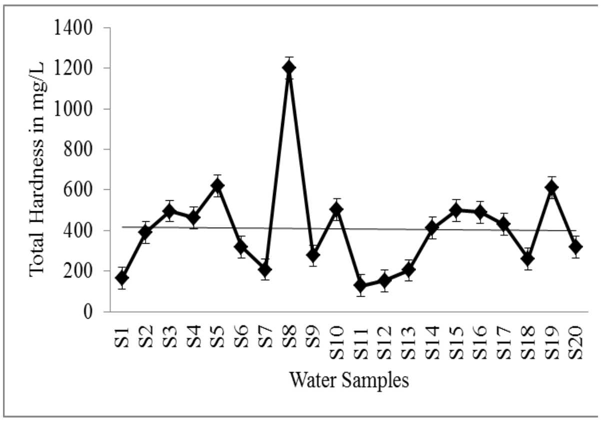

Fig (5) Variation of Total Hardness

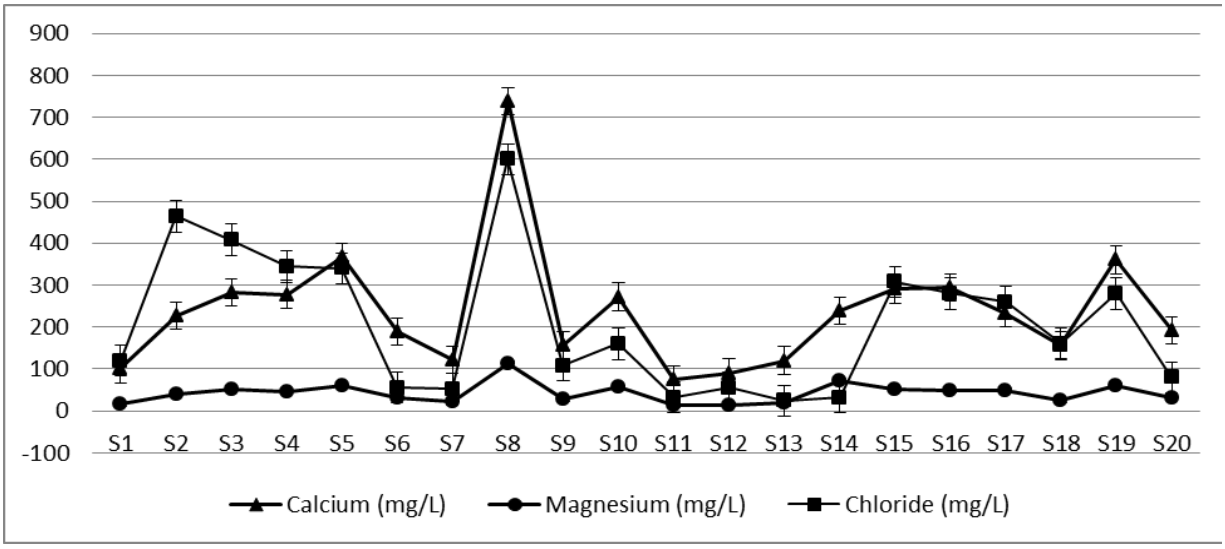

Fig (6) Variation of Calcium, Magnesium and Chloride

4.3 Total Dissolved Solids (TDS)

Total dissolved solids ranged from 232 to 1666 mg/L in the study area, whereas according to the standard 500 is the permissible and 2000 mg/L is the excessive limit. In water samples, most of the matter is in dissolved form and consists mainly of organic matter and dissolved gases, which contribute to TDS. In the study area, 75% of the samples are non – saline, whereas 25% of the samples are slightly saline and 40% lies within the permissible limit in the standard (Fig-4). Higher concentration causes hardness, scaly deposits, sediment, cloudy coloured water staining, salty or bitter taste, corrosion of pipes and fittings [14]. In the correlation matrix; TDS negatively correlates with alkalinity, and strongly correlate positively with EC, chloride, TH, calcium, magnesium and sulphates.

4.4 Alkalinity

Alkalinity is the quantitative capacity aqueous media to react with hydrogen ions. The determination of alkalinity provides an idea of the nature of salts present. 200 – 600 mg/L is the acceptable and permissible limit for total alkalinity as calcium carbonate. In all the samples, the total alkalinity was found less than the permissible limit ranging from 48 to 312 mg/L where the mean value is 124 mg/L. As the alkalinity is less than hardness, neutral salts of calcium or magnesium must be present that are not carbonates but Sulphates. The alkalinity in water leads to degradation of water quality and increases the chances of corrosion in water supply pipes [15]. In the correlation matrix; alkalinity correlates slightly negative with sulphates, fluoride, nitrate and potassium.

4.5 Total Hardness (TH)

Total hardness is the property of water which prevents the lather formation with soap and increases the boiling points of water. Hardness of water mainly depends upon the amount of calcium and magnesium salts or both and it conveys whether the water can be used for domestic, industrial or agricultural purposes or not. 200 – 600 mg/L is the acceptable and permissible limit, wherein the value ranged from 128 to 1200 mg/L with a mean value of 407.5. 15% of the samples lie within the acceptable limit whereas and 15% have crossed the permissible limit (Fig-5). Higher concentrations of hardness in water cause kidney stones, heart problems, etc [16]. In the correlation matrix; Total Hardness correlates strongly with other parameters such as calcium, magnesium and chloride (Fig-5).

4.6 Calcium (Ca^{2+})

In the study area, the Calcium ranged from 76 - 738 mg/L, where the mean value was 239 mg/L. As per the standards 75 mg/L is the acceptable limit, whereas, 200 mg/L is the permissible limit. 45% of the samples crossed more than acceptable limits and 55% have crossed the permissible limit. Calcium is one of the most abundant substances found in natural water in higher quantities in the rocks. The presence of calcium in water is mainly due to its passage through over deposits of lime, dolomite, gypsum etc. Calcium hardness causes poor lathering and deterioration of the quality of clothes, incrustation in pipes and scale formation. Irregular concentrations of calcium cause osteoporosis, kidney stones, colorectal cancer, hypertension and stroke, etc [17]. In the correlation matrix; calcium correlates negatively with fluoride, whereas positively strongly correlates with magnesium, chloride and Sulphates (Fig-6).

4.7 Magnesium (Mg^{2+})

Magnesium ranged from 12.64– 112.27 mg/L in the study area where the mean value is 42.43 mg/L. As per BIS 10500:2012 standards, 30 mg/L are the acceptable and 100 mg/L is the permissible limit for drinking. 60% of the samples ranged more than acceptable limit and 5% lies more than the permissible limit. Magnesium is washed from rocks and subsequently ends upon water, whereas in chemical industries, magnesium is added to plastics and other materials as a fire protection measure or as filler. In the environment it also comes from fertilizer application and from cattle feed. At higher concentration, magnesium salts have laxative effects causing poor lathering, deterioration of clothes, with sulphate laxative and may cause a temporary adaptable change in bowel habits (diarrhoea), but seldom causes hypermagnesaemia in persons with normal kidney function [18]. In the correlation matrix; magnesium slightly correlates with pH and sulphates negatively, whereas in it correlates highly in other parameters positively (Table – 3).

4.8 Chloride (Cl^-)

Around 55% of the samples have crossed the acceptable limits but not the permissible limits in the study area, where the chlorides ranged from 24 – 600 mg/L with a mean value of 208.2 mg/L. According to the standards, 250 mg/L is the acceptable and 1000 mg/L is the permissible limit (Fig-6). Chloride is a good indicator of groundwater quality. The chloride concentration in groundwater will increase if it is mixed with sewages, sea water, industrial effluents etc. Chlorides produce a salty taste to the water, but it varies and it depends on the chemical composition of water [14]. Higher concentrations of Chloride in water cause gastrointestinal problems, diarrhea, etc [17]. In the correlation matrix; chloride strongly and moderately correlates with all the other parameters positively other than pH (Table – 3).

4.9 Sulphates (SO_4^{2-})

Sulphates noticed with a maximum value of 16.6 mg/L in the study area with a mean value of 3.72 mg/L, whereas 200 are the acceptable and 400 mg/L is the permissible limit. All the samples value ranged less than the acceptable limits (Fig-7). Sulphate ions are relatively abundant in natural waters ranging from a few to several thousand mg/L. In the absence of dissolved oxygen, nitrate and sulphates serve as a source of oxygen for biochemical oxidation produced by anaerobic bacteria. In the correlation matrix; sulphates is strongly correlating positively in EC, TDS, TH, calcium, magnesium and chlorides.

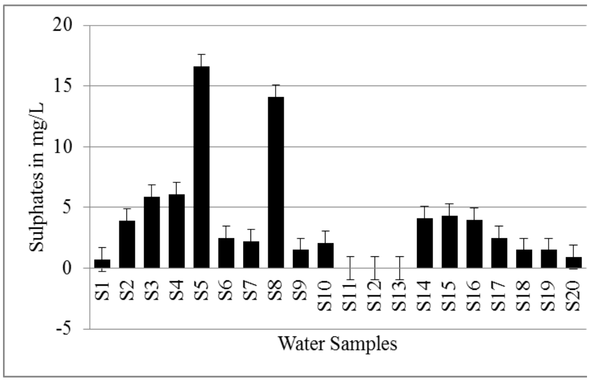

Fig (7) Variation of Sulphates

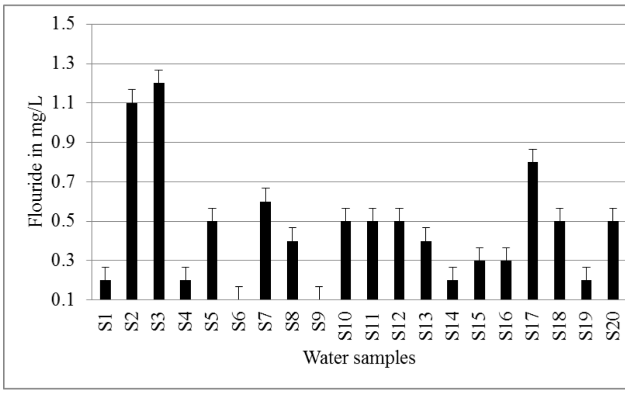

Fig (8) Variation of Fluorides

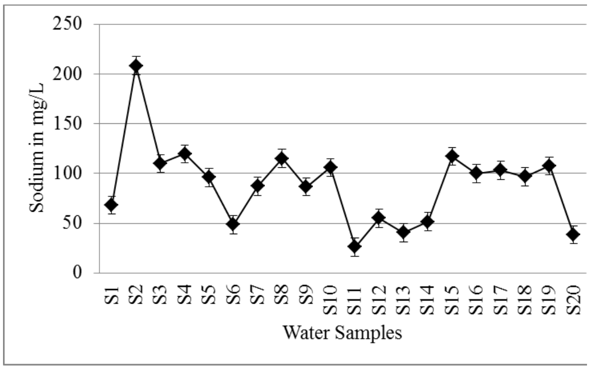

Fig (9) Variation of Sodium

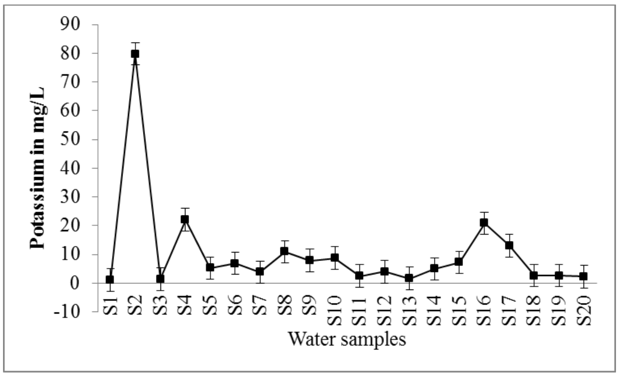

Fig (10) Variation of Potassium

4.10 Fluoride (F^-)

Fluoride observed with a ranged between 0.1 and 1.2 mg/L in the study area with mean value of 0.45 mg/L. According to the standards, 1.0 mg/L is the acceptable and 1.5 mg/L is the permissible limit for fluoride. 10% of the samples have crossed desirable limit and 90% of the samples lie within the acceptable limit (Fig-8). Fluorides in high concentration occur in detrimental concentrations in groundwater. Excess of fluorides is associated with the health risks like low to moderate doses of fluoride include: dental fluorosis, skeletal fluorosis, bone fracture, bone cancer, joint pain, skin rash, reduced thyroid activity, birth defects and IQ deficits [17]. In the correlation matrix; fluoride is slightly correlating positively with EC, TDS, TH, calcium, magnesium and chlorides.

4.11 Nitrates (NO_3^{-})

Nitrates observed with a maximum of 18 mg/L in the study area with a mean value of 3 mg/L. According to the standards, 45 mg/L is the acceptable limit, whereas there is no relaxation for the permissible limit for nitrates. All the samples showed the values less than the acceptable limit, showing that it is free from nitrates. Application of fertilizers to lands, industrial effluents, human and animal waste, seepage, leaching from solid waste dumpsite contribute nitrate to the groundwater. Nitrate is considered to be of low toxicity but causes various cancers, Methemoglobinemia (blue baby syndrome) and birth defects if concentration is above the permissible limits [19]. In the correlation matrix; nitrates strongly correlates with EC and chlorides.

4.12 Sodium (Na^{+})

Sodium ranged between 25.9 to 208.32 mg/L whose mean value is 89 mg/L (Fig-9). Cardiovascular diseases and Toxemia in pregnant women is caused due to presence of high concentration of sodium crossing 150 mg/L in water [20]. In the correlation matrix; sodium strongly correlates with EC, TDS and chlorides.

4.13 Potassium (K^{+})

Potassium ranged between 1.12 to 79.77 mg/L with a mean of 10.5 mg/L. In the correlation matrix; potassium slightly correlates with EC, chloride and fluoride (Fig-10). In order to find out the relationship amongst physico-chemical parameters of the water samples, correlation co-efficient were worked out and a large number of significant correlations were obtained (Table 3).

Table 3. Correlation Matrix of Physico-Chemical variables of Groundwater samples

Variables	**pH**	**EC**	**TDS**	**Alkalinity**	**TH**	**Ca^{2+}**	**Mg^{2+}**	**Cl^-**	**SO_4^{2-}**	**F^-**	**NO_3^-**	**Na^+**	**K^+**
pH	1												
EC	-0.393	1											
TDS	-0.431	**0.916**	1										
Alkalinity	0.722	0.031	-0.091	1									
TH	-0.276	**0.782**	**0.897**	0.102	1								
Ca^{2+}	-0.277	**0.767**	**0.895**	0.080	**0.998**	1							
Mg^{2+}	-0.289	**0.735**	**0.829**	0.088	**0.953**	**0.942**	1						
Cl^-	-0.280	**0.930**	**0.939**	0.025	**0.806**	**0.802**	**0.701**	1					
SO_4^{2-}	-0.461	**0.720**	**0.758**	-0.278	**0.776**	**0.780**	**0.735**	0.703	1				
F^-	-0.055	0.326	0.214	-0.095	0.020	-0.004	-0.002	0.379	0.096	1			
NO_3^-	-0.358	0.450	0.466	-0.129	0.360	0.382	0.274	0.386	0.441	-0.238	1		
Na^+	-0.281	**0.820**	0.644	0.106	0.440	0.420	0.387	**0.787**	0.355	0.453	0.234	1	
K^+	-0.193	0.488	0.317	-0.056	0.110	0.104	0.093	0.478	0.103	0.412	0.125	0.770	1

5. CONCLUSION

One of the major problems identified during sampling was sanitation. Near the bore wells, use of water for washing clothes, utensils, cattle etc., were encountered. Possibility of bore wells being contaminated both by microbes as well as chemicals (detergents, soaps) may be anticipated. The variation in the groundwater quality was mainly due to the impact of anthropogenic activity in the city [21]. The water quality parameters were determined by testing the water samples in the laboratory. Many of the parameters showed minimum value within the acceptable limit prescribed by BIS 10500:2012. The pH was found within the drinking water limits ranging from 7.0 to 8.1 for all the samples. The Electrical Conductivity values were found to be crossed the acceptable limits. High amount of dissolved inorganic substances or salts in ionized form causes high electrical conductivity in groundwater. Though the Total Dissolved Solids was not crossed the permissible limit (2000 mg/L), slightly higher acceptable range of TDS was noticed. Total dissolved solids indicate the salinity behaviour of groundwater. Water containing more than 500 mg/L of TDS is not considered desirable for drinking water purposes.

The determination of alkalinity provides an idea of nature of salts present. Total Alkalinity ranged less within the acceptable limit in all the samples, concluding no problem regarding alkalinity. Alkalinity has little sanitary significance, where it is used in treating water and waste waters. High alkalinity causes deterioration of plumbing and indicates the presence of heavy metals in water, which make it undesirable to use. Total hardness has crossed its permissible limits among the samples S5, S8 and S19 (values of 620, 1200 and 610 mg/L), and remaining samples found to be less than the permissible limits. Hardness in water is caused by certain salts held in solution; some of the common salts are carbonates, fluorides and sulphates of calcium and magnesium.

Whereas, the calcium content was S2, S3, S4, S5, S8, S10, S14, S15, S16, S17 and S19 (ranging from 227, 283, 278, 366, 738, 272, 239, 290, 294, 232 and 360 mg/L respectively) have crossed the permissible limit. Water with high calcium content is undesirable for household uses such as washing, bathing and laundering because of consumption of more soap and other clearing agents. Calcium and Magnesium ions in irrigation water tend to keep soil permeable and in good condition. For Magnesium, S2, S3, S4, S5, S6, S10, S14, S15, S16, S17, S19 and S20 have the value ranging more than the acceptable limit (40, 51.76, 45, 61.72, 31.83, 56, 42, 51, 47, 48, 60.75 and 31.10 mg/L respectively). Whereas in sample S8 has crossed the permissible limit (ranging at 112 mg/L) prescribed for drinking purpose.

Sulphates and nitrates have ranged less than the acceptable limit in all the samples. In S2 and S3, fluorides have crossed the acceptable limits (1.1 and 1.2 mg/L respectively). Fluoride in small amount is necessary for good health for preventing dental carries but high concentration causes health risk such as dental fluorosis and skeletal fluorosis. Higher Concentration of fluoride increases mainly through geological formation of rocks.

Overall, from the analysis of groundwater samples, S8 showed high concentration of TDS, hardness, calcium and magnesium, where it has crossed the permissible limits resulting that there is a need of proper treatment facility before use for drinking purpose. Other than this location, the groundwater quality is potable except S2 and S3 where it has crossed more than acceptable limit for fluoride which also requires treatment before consumption. From the correlation matrix, it was easy to find out the correlation between all the parameters, wherein each and every parameter showed positive as well as few negative correlations, where it correlated from highly, moderately to slightly range. It is clear from the result that, pH was negatively correlated with all the variables and was not significantly correlated with any of the studied parameters. All the variables except pH and few of Alkalinity, TDS, Calcium, Magnesium and Chloride were positively correlated.

Further, more studies are required for analysis of other parameters such as details of geology and sources of pollution to integrate among interrelated quality. The detailed scientific work is required to find solution for the various problems of groundwater quality and related problems. Artificial recharge structures like nala bunds, check dams, percolation tanks, farm ponds, subsurface dykes and de-silting of silted tanks should be constructed in the feasible areas for augmentation of groundwater resource and to improve groundwater quality.

Ground water is not only imported in health aspects of human it also sustains the base flows of rivers and important aquatic ecosystems. Due to scarce surface and ground water availability, the management of these resources is crucial. Based on the observations made in the field, mass awareness programmes should be conducted for public to conserve groundwater resources. Farmers should be encouraged to grow less water intensive crops and adopt micro irrigation system by providing subsidies. If surface water conservation takes place, automatically groundwater recharge will improves the groundwater level and increases considerably, with this to serve the future water scarcity as well as quality of water problem for the future generation.

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