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Spatial investigation of groundwater quality and its suitability for irrigation in Yalgaon dam command area in Buldhana district of Maharashtra

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Abstract
The study of groundwater quality parameters is most essential for irrigation water, and its quality is a serious problem around the study area. The spatial analysis of groundwater quality mapping is required and stimulated us to undertake a systematic work of groundwater quality parameters for suitable water exploration of crops from open wells in Yalgaon Dam command area. A detailed study of physico-chemical parameters composition of groundwater was performed from groundwater quality data of three seasons like pre-monsoon, monsoon (rainy) post-monsoon in the year of 2017 and 2018. The groundwater quality data were collected from nine villages in 20 wells samples randomly distributed in *viz:* Antri-teli, Sakhali, Yalgaon, Ruhikhed-Tekale, Sao, Sagwan, Kolwad, Nandra-koli, Ajispur in Yalgaon dam command area. GIS is a powerful tool for representation and analysis of spatial information related to groundwater resources management. To achieve this aim, the groundwater quality samples were analyzed for the preparation of groundwater quality indices such as pH, electrical conductivity, TDS, cation such as Ca, Mg, Na, K, and anions Cl, Sulphate, Bicarbonate. The results shows that the groundwater was having high salinity and low sodium hazard (C_3S_1) during pre monsoon (summer) monsoon (rainy) season, and post monsoon (winter) season, the water can be use for irrigation with adoption of proper leaching management. Among all the cations Ca^{2+}, Mg^{2+} and K^+ was below the permissible limit in all three season except seven sample where $Mg^{2+}$and Na^+ exceeds permissible limit during pre monsoon and monsoon season. Among the anions HCO_3^-, Cl^- and SO_4^{2-} were also below the permissible limit.

Keywords: Investigation of groundwater, Yalgaon, command area in Buldhana

Introduction
Ground water is a vital component of agriculture support system ground water quality directly affects soils and crops and their management. There is a growing concern on deterioration of ground water quality due to geogenic and anthropogenic activities. Regional differences in water characteristics will result from variation of geology. The chemical constituents of ground water can affect plant growth directly through toxicity or deficiency or indirectly by altering availability of essential nutrients (Ayers and Westcot, 1985) [4]. Buldhana is a western most district of Vidarbha. It lies between 19°51' to 21°17' north latitudes and 75°57' to 76°59' east longitudes and falls in survey of India Toposheets 55-A, 55-C, 55-D and 55-P.The district covers a total geographical area of 9670.00 sq.km. Ground Water Quality CGWB is monitoring the ground water quality of the Buldhana district for the last four decades through its monitoring wells. The objectives behind the monitoring are to develop an overall picture of the ground water quality of the district. During the year 2011, the Board has carried out the ground water quality monitoring of 27 monitoring wells. These wells mainly consist of the dug wells representing the shallow aquifer. The parameters analyzed, include pH, Electrical Conductivity (EC), Total Alkalinity (TA), Total Hardness (TH), Nitrate (NO_3) and Fluoride (F). The sample collection, preservation, storage, transportation and analysis were carried out as per the standard methods given in the manual of American Public Health Association for the Examination of Water and Wastewater (APHA, 1998) [3]. The ground water quality data thus generated was first checked for completeness and then the validation of data was carried out using standard checks. Subsequently, the interpretation of data was carried out to develop the overall picture of ground water quality in the district in the year 2011.

Ground water quality is Good and suitable for drinking and irrigation purpose, however localized nitrate contamination is observed.

The chemical properties of ground water bears equal importance with its quantity. As word population growth continue and modern industrial and agricultural processes introduced an increasingly a complex suite of chemical constituent into the environment, scientist have begun to take a serious look at their effect on surface and groundwater quality. The groundwater quality is influenced both by surface physical environment and by the environment where recharge takes place. The chemical quality of groundwater depends most on composition of the host rock and also depends on the location of sources and state of environment protection in high content of total soils like fluorides, iron and manganese are the special characteristics of some ground water acquired through geo contamination and sea water intrusion. The quality of irrigation water is directly concern with the degree of weathering, movement of groundwater, individual ion-contents and ion-exchange, climate and the time variation in the process of recharge and discharge. In arid and semi-arid areas, ground water is considered the major source of usable water, so that quality of water is the main key factor in management of groundwater in a sustainable manner. In the past few decades, reports of ground water contamination have increased public concern about its quality. Subsurface leaching of contaminants from land-fills as well as seepage from canals, rivers and drains cause severe degradation of the ground water quality. Adsorption and dispersion processes in the soil zone, degrees of evaporation, recharge and lateral inter-mixing of ground water determine the level of contaminations in ground water. Exploitation of vital ground water source leads to lowering of the ground water table and water quality deterioration. The groundwater pollution in different countries was mainly due to lack of proper waste management.

Study Area

The study area comprises parts of nine villages in the Yalgaon Dam command area of Taluka Buldhana, District Buldhana, Maharashtra (Table 1).

Table 1: Water sample location near by the Yalgaon command dam in Buldhana district

Water samples	Village name	Latitude	Longitude	Water source
W_1	Antri-Teli	20^0. 46' N	76^0.22' E	WELL
W_2	Antri-Teli	20^0. 46' N	76^0.21' E	WELL
W_3	Sakhali	20^0.46' N	76^0.20' E	WELL
W_4	Sakhali	20^0.46 'N	76^0.20' E	WELL
W_5	Yalgaon	20^0.48'N	76^0.20' E	WELL
W_6	Yalgaon	20^0.49' N	76^0.20' E	WELL
W_7	Yalgaon	20^0.49' N	76^0.14' E	WELL
W_8	Yalgaon	20^0.52' N	76^0.16 'E	WELL
W_9	Ruhikhed Tekale	20^0.48' N	76^0.24' E	WELL
W_{10}	Ruhikhed Tekale	20^0.48' N	76^0.24' E	WELL
W_{11}	Sao	20^0. 48' N	76^0.23' E	WELL
W_{12}	Sao	20^0.48' N	76^0.21' E	WELL
W_{13}	Sagwan	20^0.46 'N	76^0.20' E	WELL
W_{14}	Sagwan	20^0.48'N	76^0.20' E	WELL
W_{15}	Kolwad	20^0.49' N	76^0.16' E	WELL
W_{16}	Kolwad	20^0.49' N	76^0.14' E	WELL
W_{17}	Nandra-koli	20^0.51' N	76^0.15' E	WELL
W_{18}	Nandra-koli	20^0.52' N	76^0.15' E	WELL
W_{19}	Ajispur	20^0.48' N	76^0.16' E	WELL
W_{20}	Ajispur	20^0.52' N	76^0.16' E	WELL

Material and Methods

Ground water quality data were collected form open and dung wells. All samples were labeled properly, and according to the prerequisites for the water quality parameters like EC, pH, TDS, Ca and Mg were analyzed in the yalgaon dam command area. The sample was collected twenty different locations of Buldhana region during pre monsoon, monsoon season and post monsoon season, were analyzed various parameters of water *viz*., pH, EC, Calcium (Ca^{2+}), Magnesium (Mg^{2+}) Sodium (Na^{+}), Potassium (K^{+}), Carbonate (CO_3^{2-}), Bicarbonate (HCO_3^{-}) Chloride (Cl^{-}), Sulphate (SO_4^{2-}). The sample were analyzed by the standard method protocols.

Results and Discussion

The spatial and the attribute database generated the integrated for the generation of spatial variation maps of major water quality parameters EC, pH, TDS, Ca and Mg etc. A ground water quality map has been showed which suitable wells for irrigation purpose at the yalgaon dam command area.

General Hydrochemistry of groundwater

pH is one of the important parameter of water and determines the acidic and alkaline nature of water. The pH of ground water was found in the range of 7.13 to 8.27, 7 to 7.85 and 6.87 to 7.44 during pre monsoon, monsoon and post monsoon season respectively (Table 2). The highest pH was recorded in sample (W1), which was collected from Antri-teli village during pre monsoon season, while the lower during post monsoon season in sample (W14) which was collected from village Sakhali. This clearly indicated that during the post monsoon season the ground water level increased which results in to dilution of water and reduces the pH of ground water. Jana (1973) [9] was also reported that the higher pH concentration during pre monsoon season. The ground water pH was found below permissible limit in all the three season.

Electrical Conductivity

Electrical conductivity is the ability of a substance to conduct an electrical current, measured in desi-Siemen per metre

(dS/m). Ions such as sodium, potassium, chloride give water its ability to conduct electricity. Conductivity is an indicator of the amount of dissolved salts in a stream which is often used to estimate the amount of total dissolved solids (TDS) rather than measuring each dissolved constituent separately. The data pertaining in (Table 2) have had shown the status of electrical conductivity of ground water in Yalgaon dam command area. The range was found in between 0.69 to 1.99, 0.74 to 1.79 and 0.61 to 1.95 dSm^{-1} during pre monsoon, monsoon and post monsoon season respectively. The result indicated that the higher value of electrical conductivity was recorded during pre monsoon, whereas lower of electrical conductivity was recorded during monsoon, whereas slightly higher during post monsoon season. The three season's data shoes that all samples falls in class (C3). The results indicated the electrical conductivity of water was within the permissible limit. Similar observations were recorded by Joseph and Kannan, (2009) [10]. According to Trivedy and Goel, (1984) [17] the seasonal variation in conductivity was mostly due to increase in concentration of salts due to evaporation. The result indicates that the ground water is safe for irrigation during all three seasons for specific soil conditions.

Total Dissolved Solids (TDS)

Total dissolved solids generally reflect the amount of dissolved mineral content in water and control its suitability for further use. High concentration of total dissolved solids causes adverse effects on soil properties (Rajput and Polara, 2013) [14]. The data in respect of total dissolved solids have been compiled (Table 2). The data indicated the remarkable variation in total dissolved solids. The water sample collected from twenty different locations, Indicated the major variations. The highest TDS was noted in sample (W7) and (W10) which was collected from village's *viz*. Sao, and Yalgaon, while the lower was at Yalgaon. The TDS of water getting lowered during post monsoon periods against the pre monsoon. The percolation of rainwater in sub-soil encourages the dilution of ground water which ultimately helps to reduce the total dissolved solids. The total dissolved solids in ground water was in the range of 441.6 to 1273.6, and 544 to 1145.6, 390.4 to 1248 mgL^{-1} in pre monsoon, monsoon and post monsoon season, respectively which was below permissible limit for irrigation. Total dissolved solids are directly related to electrical conductivity. The high TDS was recorded during pre monsoon and the lower concentration of TDS was recorded during monsoon season and slightly high during post monsoon season. The Increase in TDS might be due to the addition of various pollutants, which may be imbedded in the water and cause harmful effects on plant (Matthess, 1982) [12].

Table 2: pH, Electrical conductivity and Total dissolved solids (mgL^{-1}) of ground water in Yalgaon dam command area of Buldhana

Source	Pre monsoon (Summer)	Monsoon (Rainy)	Post monsoon (Winter)	Pre monsoon (Summer)	Monsoon (Rainy)	Post monsoon (Winter)	Pre monsoon (Summer)	Monsoon (Rainy)	Post monsoon (Winter)
	pH			EC (dSm^{-1})			TDS (mgL^{-1})		
W_1	8.27	7.5	7.21	1.65	0.74	1.0	1056	473.6	640
W_2	7.55	7.67	7.24	1.71	0.79	0.91	1094.4	505.6	582.4
W_3	7.92	7.74	7.36	1.45	0.77	0.83	928	492.8	531.2
W_4	7.94	7.78	6.87	1.3	0.89	0.99	832	569.6	633.6
W_5	7.24	7.85	7.36	1.77	1.28	1.58	1132.8	819.2	1011.2
W_6	7.72	7.83	7.41	1.77	0.85	0.92	1132.8	544	588.8
W_7	7.9	7.26	7.05	1.99	1.25	1.7	1273.6	800	1088
W_8	7.78	7.3	7.15	1.72	1.54	1.69	1100.8	985.6	1081.6
W_9	7.31	7	7.16	1.4	1.79	1.81	896	1145.6	1158.4
W_{10}	7.43	7.16	7.11	1.99	1.6	1.43	1273.6	1024	915.2
W_{11}	7.9	7.74	6.98	0.69	1.21	0.61	441.6	774.4	390.4
W_{12}	7.53	7.22	7.05	1.82	1.66	1.73	1164.8	1062.4	1107.2
W_{13}	7.33	7.23	6.95	1.27	1.25	1.2	812.8	800	768
W_{14}	7.43	7.8	7.11	1.22	1.11	1.2	780.8	710.4	768
W_{15}	7.19	7.84	6.95	1.5	1.44	1.32	960	921.6	844.8
W_{16}	7.44	7.36	6.99	1.86	1.63	1.79	1190.4	1043.2	1145.6
W_{17}	7.2	7.13	7.11	1.72	1.52	1.69	1100.8	972.8	1081.6
W_{18}	7.55	7.27	7.07	1.98	1.57	1.68	1267.2	1004.8	1075.2
W_{19}	7.33	7.7	7.44	1.89	1.39	1.79	1209.6	889.6	1145.6
W_{20}	7.13	7.36	7.28	1.98	1.6	1.95	1267.2	1024	1248
Mean	7.55	7.48	7.14	1.63	1.29	1.41	1045.76	828.16	902.72
SD	0.31	0.28	0.16	0.33	0.34	0.40	213.5	214.8	251.13
CV	4.14	3.80	2.30	20.42	25.93	28.97	20.4	25.9	29.0
Range	7.13 - 8.27	7 - 7.85	6.87 -7.44	0.69-1.99	0.74-1.79	0.61-1.95	441.6 -1273.6	544 -1145.6	390.4 -1248
Permissible limit	6.5-8.4			0.75 - 2.25			500-1500		

Cation content in ground water (meL^{-1})

Calcium

The calcium content in ground water during pre monsoon, monsoon, and post monsoon season is placed in (Table 3). The data shows that the remarkable variation in calcium in the water samples collected from twenty different locations. The highest calcium was noticed in sample (W_{10}) in monsoon season which was collected from village Yalgaon, while the lower was in Antri-teli in post monsoon season. The calcium of water getting lowered during post monsoon period than the pre-monsoon and monsoon which clearly indicates that the permissible limit of calcium content in ground water is <20 meL^{-1}. By considering this limit all the analyzed samples found within safe limit. The concentration of calcium was in the range of 3.5 to 7.7, 2.1 to 9.9 and 1.9 to 6.3 meL^{-1}during pre monsoon, monsoon and post monsoon season respectively, which gives fair idea about seasonal variation which might be due to post rainfall effect (Paliwal and Maliwal, 1971) [13].

Magnesium

The magnesium content in ground water was in the range of 0.5 to 9.1, 0.1 to 4.8 and 0.6 to 4.4 meL^{-1} during pre monsoon; monsoon and post monsoon season respectively (Table 3). The content of magnesium was higher during pre monsoon and lower during post monsoon season because of after monsoon season volume of ground water was more as compare to other two seasons which was increase the dilution and lower the magnesium content in ground water. The magnesium content in ground water during pre monsoon, monsoon and post monsoon season was within permissible limit (<5 meL^{-1}) except seven sample which was collected from Yalgaon (W_5), Ruhikhed-tekale (W_9), Sao (W_{12}), Sagwan (W_{12}), kolwad (W_{15}), Nandra-koli (W_{18}), Ajispur (W_{19}) were higher than permissible limit and relatively lower as compared to the calcium which may be good because of magnesium deteriorates the soil structure by forming thick layer around clay particle which increases its size and absorb more water and increase diffusion reported as a Adamu, 2013 [2].

Potassium

The potassium content in ground water of Yalgaon dam command area is placed in Table 3. The potassium content in ground water was in the range of 0.06 to 0.42, 0.01 to 0.16, and 0.01 to 1.00 meL^{-1} during pre monsoon, monsoon and post monsoon season respectively which was below the permissible limit i.e.< 2 meL^{-1} in all the three seasons.

Table 3: Cation content of ground water in Yalgaon dam command area of Buldhana

Source	Pre monsoon (Summer)	Monsoon (Rainy)	Post monsoon (Winter)	Pre monsoon (Summer)	Monsoon (Rainy)	Post monsoon (Winter)	Pre monsoon (Summer)	Monsoon (Rainy)	Post monsoon (Winter)	Pre monsoon (Summer)	Monsoon (Rainy)	Post monsoon (Winter)
	Calcium (meL^{-1})			Magnesium (meL^{-1})			Sodium (meL^{-1})			Potassium (meL^{-1})		
W_1	3.5	3.3	1.9	3.8	3.7	1.6	12.24	1.68	5.70	0.07	Trace	0.02
W_2	4.2	3.1	2.9	1.9	1.6	2.1	13.69	1.59	3.99	0.06	0.02	0.01
W_3	3.7	4.9	2.33	1.5	0.1	1.47	10.12	1.49	4.84	0.14	0.03	0.02
W_4	4	3.8	3.1	0.5	3.1	1	9.81	1.54	4.43	0.11	0.03	0.13
W_5	3.9	3.2	2.9	6.4	0.8	1.9	13.88	3.35	8.89	0.08	0.03	0.01
W_6	3.8	4.5	2.9	1.8	2.4	1.5	12.95	1.45	4.35	0.14	0.02	Trace
W_7	5.3	4.3	4.95	1.9	1.1	3.6	14.64	5.82	8.39	0.13	0.01	0.02
W_8	3.8	4.8	5.6	2.5	4.3	4.4	22	4.17	6.21	0.10	0.05	0.01
W_9	5.2	5.6	6.3	5.3	6	0.6	12.04	4.64	6.16	0.07	0.02	0.02
W_{10}	5.2	9.9	5.4	3.8	2.4	3.7	14.1	1.44	4.51	0.12	Trace	0.01
W_{11}	4.2	6.2	3.5	4.8	0.8	2.8	4.5	4.63	1.26	0.06	0.01	0.01
W_{12}	4.3	8.9	5	9.1	4.2	2.7	13.03	1.05	6.82	0.09	0.01	0.01
W_{13}	6.2	5.3	4.4	6.6	1.2	2.5	8.87	1.00	4.58	0.07	0.00	0.02
W_{14}	4.6	7.3	4.12	3.7	3.6	3.8	7.76	0.91	3.79	0.06	0.01	0.01
W_{15}	5.1	6.8	2.9	9	1.7	1.8	10.72	4.84	1.73	0.06	0.01	0.01
W_{16}	5	6.3	4.47	3.2	0.6	2.5	14.45	3.51	6.33	0.17	0.01	0.02
W_{17}	6	7.6	5	2	3	3.2	10.58	2.96	6.02	0.07	Trace	0.01
W_{18}	5.6	7.5	3.5	7.2	4	3.6	11.74	4.00	5.90	0.02	0.16	0.01
W_{19}	5.2	2.1	5.37	8.4	4.8	1.8	13.72	1.82	6.87	0.29	0.03	0.16
W_{20}	7.7	2.5	5.7	1.7	1.7	1.0	15.4	3.44	4.13	0.42	0.03	1.00
Mean	4.82	5.39	4.11	4.25	2.55	2.37	12.31	2.76	5.24	0.11	0.02	0.07
SD	1.04	2.15	1.28	2.70	1.62	1.08	3.51	1.54	1.90	0.09	0.03	0.22
CV	21.61	39.86	31.05	63.49	63.51	45.21	28.53	55.68	36.14	78.64	144.59	293.33
Range	3.5 - 7.7	2.1 - 9.9	1.9 - 6.3	0.5 -9.1	0.1 – 6.0	0.6 – 4.4	4.5 – 22	0.91 – 5.82	1.26 -8.89	0.02 - 0.42	Trace - 0.16	Trace - 1.00
Permissible limit	< 20			< 5			<3 meL^{-1}			< 2 meL^{-1}		

Sodium

The sodium content in ground water of Yalgaon command area was assessed and the data generated is placed in Table 3.The sodium content was ranged in between 4.5 to 22 meL^{-1} during pre monsoon season which exceeds the safe limit of < 3 meL^{-1}, whereas during monsoon season 11 samples were categorized below safe limit (W_1, W_2, W_3, W_4, W_6, W_{10}, W_{12}, W_{13}, W_{14}, W_{17}, W_{19},) and rest of the samples exceeds the safe limit, but in post monsoon season the sodium content in ground water was in the range of 1.26 to 8.89 meL^{-1}, Two samples falls below the safe limit (W_{15}, W_{11}) and rest of the samples exceeds the safe limit. It might be due to highest volume of sodium during pre monsoon season due to shrinkage of water volume observed in Solanki, 2001 [16]. The evaporation of the water is significant factor in increasing the sodium level during summer season. In a nut shell it can be concluded that the sodium was the dominant cation in ground water followed by calcium, magnesium and potassium, $Na^+ > Ca^{2+} > Mg^{2+} > K^+$. Babhulkar *et al.*, 2009 reported that the dominancy of Na^+ over Ca^{2+} and Mg^{2+} may be one of the geological causes for development of native sodicity in soil. The ground water that has high sodium (Na^+) content can bring about a displacement of exchangeable cation Ca^{2+} and Mg^{2+} from the clay minerals of the soil, followed by the replacement of the cations by sodium Islam and Shamsad, 2009 [8].

Anion content in ground water (meL^{-1})

Bicarbonate

The bicarbonate content in ground water was in the range of 2.6 to 7.6, 1.6 to 6.4 and 1.7 to 6.65 meL^{-1} during pre monsoon, monsoon and post monsoon season respectively which was higher during pre monsoon and post monsoon season. Most of the values of water sample of three season fall below the degree of restriction water for irrigation use (UCCC, 1974) [18]. The coefficient of variance during pre

monsoon season was high over the monsoon and post monsoon season it indicate the variation among the quality of ground water of various places. The bicarbonate content can bring about a change in soluble sodium percentage in irrigation water which regulates the sodium hazards (Adhikary and Biswas, 2011) [1]. The carbonate content was nil during all three seasons.

Chloride

The data in respect of chloride have been compiled and placed in Table 4.The results shows that the remarkable variation in chloride. The highest chloride content in irrigation water was recorded in sample (W_{10}) during pre monsoon and monsoon season, which was collected from village Yalgaon. The chloride content of water lowered during post monsoon periods than the pre monsoon season. The chloride content of ground water was in between 2.6 to 5.4, 2.2 to 5 and 1.6 to 4.8 meL^{-1} in pre monsoon, monsoon, and post monsoon season respectively, which exceed the permissible limit of <4 meL^{-1}. Similar results were also recorded by Billore (1981) [6] increase in chloride concentration in lake water during summer season. Islam *et al.*, 2009 [8] Indicates the impact of settlement and anthropogenic effect. According to Adhikary and Biswas, (2011) [1] observed that the chloride content normally increases as the mineral content increase and reduced phosphorus availability to plants. The percolation of rainwater in subsoil encourages the dilution of ground water which ultimately helps to reduce the chloride content.

Table 4: Anion content of ground water in Yalgaon dam command area of Buldhana

Source	Pre monsoon (Summer)	Monsoon (Rainy)	Post monsoon (Winter)	Pre monsoon (Summer)	Monsoon (Rainy)	Post monsoon (Winter)	Pre monsoon (Summer)	Monsoon (Rainy)	Post monsoon (Winter)
	Bicarbonate content (meL^{-1})			Chloride content (meL^{-1})			Sulphate content (meL^{-1})		
W_1	6.2	3.3	3.5	4.2	3.6	1.6	8.72	6.76	7.97
W_2	6.0	3.9	4.4	4.4	3.4	2.4	4.36	2.89	3.96
W_3	6.2	3.8	4.3	2.6	3.0	2.4	4.99	3.96	4.33
W_4	6.0	1.6	1.7	2.8	2.7	2.3	3.87	3.51	5.88
W_5	4.5	3.8	4.0	3.1	2.8	2.6	10.68	9.68	10.00
W_6	7.4	3.9	3.9	4.4	3.3	2.6	10.41	9.75	10.22
W_7	6.0	4.9	5.0	4.8	3.8	4.0	12.98	10.26	10.80
W_8	5.8	4.3	4.6	4.4	3.0	2.6	10.50	9.93	10.20
W_9	5.1	4.9	5.2	3.6	3.4	3.2	10.97	9.98	9.98
W_{10}	4.2	3.2	3.6	5.4	5.0	4.8	11.36	10.43	10.50
W_{11}	2.6	4.5	5.4	4.4	4.0	3.0	6.59	4.14	4.20
W_{12}	6.3	6.4	7.6	5.0	4.8	4.3	10.02	7.44	8.61
W_{13}	3.5	2.3	3.5	4.6	4.0	3.2	8.87	6.41	7.56
W_{14}	4.2	3.8	3.8	3.2	2.8	2.2	10.77	6.91	7.49
W_{15}	5.2	4.1	4.7	3.8	2.3	2.8	10.37	8.78	9.00
W_{16}	5.5	4.5	4.8	4.6	4.2	4.0	11.02	9.76	10.02
W_{17}	5.0	4.5	4.7	3.8	3.0	2.6	12.06	9.92	10.32
W_{18}	5.9	4.6	5.6	4.0	3.8	3.9	14.26	10.07	10.80
W_{19}	7.6	6.2	6.6	3.6	2.2	3.8	15.23	11.83	13.45
W_{20}	7.4	5.3	6.65	4.2	2.4	4.0	16.36	12.36	13.20
Mean	5.53	4.19	4.67	4.04	3.37	3.11	10.21	8.23	8.92
SD	1.29	1.13	1.31	0.73	0.78	0.85	3.34	2.83	2.71
CV	23.29	27.00	28.07	18.16	23.13	27.25	32.73	34.31	30.34
Range	2.6 -7.6	1.6 -6.4	1.7 -7.6	2.6 -5.4	2.2- 5	1.6 - 4.8	3.87 -16.36	2.89 -12.36	3.96 -13.45
Permissible limit	< 10 meL^{-1}			<4 meL^{-1}			< 20 meL^{-1}		

Sulphate

The sulphate content in ground water was presented in the Table 4. The range of 4.36 to 16.36, 2.89 to 12.36 and 4.2 to 13.45 meL^{-1} during pre monsoon, monsoon and post monsoon season respectively, which was within the normal permissible limit for irrigation water given by Richards (1954) [15]. Bheemappa *et al.*, (2015) [7] reported that the runoff from fertilized land contribute sulphate to water body. Sulphate is relatively common in irrigation water and has no major effect on the soil other than contributing to the total salt content. Ground water high in sulphate ion reduced phosphorus availability to plants reported by Khalil and Arther (2010) [11].

Conclusion

Form this study it can be concluded that the irrigation water collected from ground water source during pre monsoon, monsoon season and post monsoon season falls in high salinity and low sodium hazard class (C_3S_1). Therefore, the collected water is advisable for irrigation by adopting proper management practices and the irrigation water content appreciable amount of nutrient element which can substitute fertilizer up to same extent.

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