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Assessment of groundwater quality under semi-arid micro-watershed condition

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Abstract: The seasonal groundwater quality of the Patapur micro-watershed was assessed through existing bore wells in Raichur was studied. The chemical parameters namely pH, EC, SAR, sodium (Na^+), potassium (K^+), calcium (Ca^{++}), magnesium (Mg^{++}), carbonate (CO_3), bicarbonate (HCO_3^-), nitrate (NO_3^-), fluoride (F^-), chloride (Cl^-) and sulphate (SO_4^{2-}) pertaining to groundwater sources of thirteen tube wells were analyzed during pre-monsoon (June 2013), monsoon (Oct. 2013) and post-monsoon (Jan. 2014) seasons. The periodical analysis of groundwater samples collected from the representative tube wells located in the study area revealed that the parameters such as pH (7-8.5), EC (0.83-1.32 dS/m), sodium (2-210 mg/l), potassium (0.3-14.5 mg/l), nitrate (1.1-10.6 mg/l) and sulphates (0.4-10.6 mg/l) were within the permissible limits and there are no abnormal changes during the study barring minor variation in few wells during pre-monsoon. The parameters such as SAR (0.22-23), calcium (36-960 mg/l), magnesium (43-518 mg/l), carbonates (34-370 mg/l), fluoride (0.8-2.3 mg/l) and bicarbonates (62-592 mg/l) varied rapidly during pre-monsoon, monsoon and post-monsoon. Therefore, tube well water for irrigation parameters needs to be monitored on continuous basis to maintain the soil health in the study area.

Key words: Groundwater quality, Irrigation parameters, Permissible limits, Soil health

Introduction

Human needs are growing rapidly and the need for water is also growing. Much of the current concern with regards to environmental quality is focused on water because of its importance in maintaining the human health and health of the ecosystem. Earth surface is acting as an effective filtrate to filter out particulate matters like leaves, soils, bugs, dissolved chemicals and gases. Above matters also occur in large concentrations to change the physico-chemical properties of groundwater. The uses of fertilizers, pesticides, manure, lime, septic tank, refuse dump, etc. are the main sources of bore wells water pollution. Water quality is based on the physical and chemical soluble constituents due to weathering of parent rocks and anthropogenic activities. In many of villages in Karnataka including Raichur district groundwater is only source of drinking water, thus a large population is exposed to risk of consuming contaminated water. In general, Fluoride, nitrates, iron and salinity are the major constituents of groundwater affecting the water quality.

Material and methods

In order to assess the hydro-geochemical parameters pertaining to micro-watershed area (541.39 ha) a total of 13 groundwater samples were collected from each of 13 tube wells by following standard procedure. The chemical parameters *viz.,* pH, fluoride, and electrical conductivity (EC) were measured using digital pH, EC, SAR, Na, K Ca, Mg, F^-, CO_3^-, HCO_3^-, Cl^-, SO_4^{2-}, and NO_3^- were analyzed following standard procedure during pre-monsoon (June 2013) monsoon (Oct. 2013) and post-monsoon (Jan. 2014). The purpose of evaluation of chemical characteristics of groundwater was to find out the suitability of groundwater for irrigation use and all results are compared with FAO (Food and Agriculture Organization) standard limit.

The present study was taken up in Patapur micro-watershed having an area of 541.39 ha being located in the Patapur village in Manvi taluk of Raichur district in Karnataka (Fig 1). The Patapur study area lies between the 16° 07' 35.9'' Latitude and 76° 512 33.3'' Longitudes and 16° 082 22.3'' Latitude and 76° 532 27.7'' Longitudes with an average elevation of 447 m above the mean sea level. This watershed is located about 63 km from the Raichur city on Raichur-Lingasugur road and it is falling under the Survey of India toposheet of 56 D/16 (1:50,000). The climate of the region could be termed as semi-arid with mild winters and

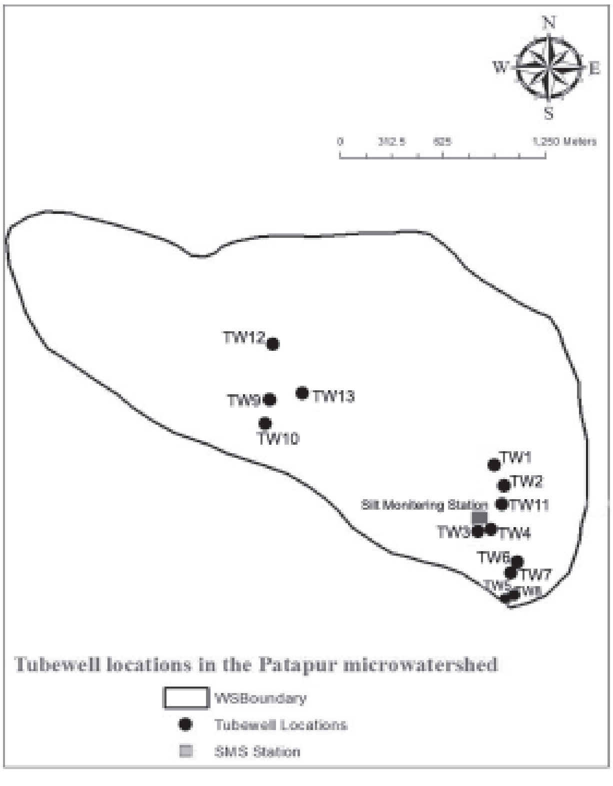

Fig 1. Location of tube wells in Patapur micro-watershed

hot summers. December is the coldest month with mean daily minimum temperature of 17.7ºC, while May month being the hottest month with mean daily maximum temperature of 39.8ºC. Relative humidity of around 75 per cent prevails during monsoon period. Wind speed exceeding 15 km/h during the months of June and July. The recorded annual potential evaporation would be 1950 mm (year), maximum (220 mm) in May month and lowest in December (120 mm). The average annual rainfall of the district is 621 mm.

Results and discussion

The obtained results are tabulated and compared with FAO standards to evaluate the suitability of groundwater for irrigation purpose.

The pH value is an important factor in maintaining the carbonate and bicarbonate levels in water and also it is used to indicate the alkalinity or acidity of a substance (strength of the water to react with the acidic or alkaline material present in the water). The pH values measured in the tube wells ranged from 7.11 to 8.03 during pre-monsoon (June 2013), 7 to 7.67 during monsoon (Oct. 2013) and 7.13 to 8.05 during post- monsoon (Jan. 2014) (Table 1). The slight alkalinity may be due to the presence of bicarbonate ions, which are produced by the free combination of CO_2 with water to form carbonic acid, which affects the pH of the water. Carbonic acid (H_2CO_3) dissociates partly to produce (H^+) and bicarbonate ions. The mild alkalinity indicates the presence of weak basic salts in the soil. There are no abnormal changes in groundwater samples. It was observed that, the concentration of pH decreases during monsoon as compared to pre-monsoon and post monsoon respectively. The results obtained were found within the permissible limit (5-9) as prescribed by the FAO standards for irrigation water quality. Water could be used for irrigation purpose in all the sampling stations of the study area. These results are in agreement with the earlier findings of Mohamed and Zahir (2012).

The importance of electrical conductivity (EC) is its measure of salinity and also it is a measure of a material's ability to conduct an electric current so that the higher EC indicates the enrichment of salts in the groundwater which greatly affects the taste and has significant impact of the user acceptance of the water as potable. The measured values of EC in the tube wells of the study area ranged from 0.83 to 1.14 dS/m during pre-monsoon (June, 2013), 0.86 to 1.3 dS/m during monsoon (Oct. 2013) and 0.86 to 1.32 dS/m during post-monsoon (Jan. 2014) (Table 1). Obtained results revealed that the EC during every season are found to be within the permissible limits of FAO (<1.5 dS/m) standards for irrigation water quality. The low values of electrical conductivity indicate the lesser dissolution of carbonate minerals and other ionic species in water. These results are in agreement with the earlier findings of Anita and Umayoru (2013).

SAR is an expression of the sodium hazard of irrigation water. It is the measure of the proportion of sodium to calcium and magnesium in the water. The SAR is also an index of the sodium permeability hazard as water moves through the soil. The main problem with a high sodium concentration is its effect on the physical properties of soil. This breakdown disperses the soil clay and causes the soil to become hard and compact when dry and reduces the rate of water penetration when wet. A breakdown in the physical structure of the soil can occur with continued use of water with a high SAR value. The effects of high SAR on the infiltration of irrigation water are dependent on the EC of the water. Generally, if the SAR is more than 10 times greater than the EC, then poor water infiltration will occur. The values of SAR found in the tube wells ranged from 2.57 to 23 during pre-monsoon (June, 2013), 5 to 19.39 during monsoon (Oct. 2013) and 0.22 to 21.57 during post- monsoon (Jan. 2014) (Table 1).

The SAR were found exceeding the permissible limit (<10) except TW_3, TW_4, TW_5, TW_7, TW_8, TW_9, TW_{10}, and TW_{13} during Pre-monsoon (June 2013), TW_3, TW_5 TW_9, TW_{12} and TW_{13} during monsoon (Oct. 2013) and TW_1, TW_2, TW_9 and TW_{13} during post-monsoon (Jan. 2014), as prescribed by FAO (<6) standards for irrigation use. Hardness of water is caused by the presence of multivalent metallic cations and is largely due to calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions. These results are in agreement with the findings of Ahamed *et al.* (2013).

Sodium is the sixth most abundant element in the earth's crust and sodium stems from rocks and soils. Percolation of river water containing high ionisable salts and the intrusion of domestic sewage probably enhances the sodium concentration, sodium is found in association with high concentration of

Table 1. Measured groundwater salinity (pH, EC and SAR) parameters during water year 2013-14

Well No.	Pre-monsoon			Monsoon			Post-monsoon		
(Location)	pH	EC (dS/m)	SAR	Ph	EC (dS/m)	SAR	pH	EC (dS/m)	SAR
TW_1	7.11	1.01	23.51	7.47	1.15	14.85	7.73	1.11	5.36
TW_2	7.75	1.03	20.43	7.67	1.17	18.98	7.54	1.17	0.22
TW_3	8.03	0.88	8.95	7.32	1.02	9.41	7.49	0.99	17.15
TW_4	8.00	0.93	9.87	7.06	1.04	13.24	7.62	1.07	21.57
TW_5	7.82	0.93	8.52	7.50	0.95	9.91	7.70	1.01	11.60
TW_6	7.76	1.14	11.05	7.40	1.30	16.06	7.67	0.99	17.49
TW_7	7.84	0.98	8.10	7.47	1.05	14.16	7.49	1.00	18.53
TW_8	7.89	0.93	5.98	7.39	0.96	11.45	8.05	1.03	13.58
TW_9	7.92	0.83	2.57	7.16	1.01	5.45	7.40	1.07	7.97
TW_{10}	7.74	1.13	4.23	7.57	1.29	19.39	7.24	1.32	12.26
TW_{11}	7.21	1.01	10.36	7.54	1.00	13.86	7.58	1.13	18.29
TW_{12}	7.35	0.95	11.66	7.05	0.94	5.00	7.71	1.01	19.36
TW_{13}	7.60	1.03	9.62	7.00	0.86	5.29	7.13	0.86	5.10

chloride resulting in salinity. Sodium concentrations are also influenced by the cation exchange mechanism. The values of sodium found in the study area ranged from 64 to 210 mg/l during pre-monsoon (June, 2013), 69 to 230 mg/l during monsoon (Oct. 2013) and 2 to 210 mg/l during post-monsoon (Jan. 2014) (Table 2). The results revealed that the all the samples were within the permissible limits of FAO (70-180 mg/l) guidelines for irrigation standards except TW_1, TW_2, TW_6, TW_{12} and TW_{13} during pre-monsoon (June 2013), TW_1, TW_2, TW_6 and TW_{10} during monsoon (Oct. 2013) and TW_4, TW6, TW_{11} and TW_{12} during post-monsoon (Jan. 2014).

Potassium is an essential element for humans, plants and animals, and derived in food chain mainly from vegetation and soil. The main sources of potassium in ground water include rain water, weathering of potash silicate minerals, use of potash fertilizers and use of surface water for irrigation. In the study area sodium values varied from 0.3 to 5.5mg/l during pre-monsoon (June 2013), 0.4 to 1 mg/l during monsoon (Oct. 2013) and 0.5 to 14.5 mg/l during post-monsoon (Jan. 2014) (Table 2). The results for potassium revealed that the all the samples were within the permissible limits (5-10 mg/l) as prescribed by FAO standards for irrigation water quality standards and groundwater samples could be used for irrigation purpose except TW_{10} in post monsoon (Jan. 2014) season.

The calcium is an important element to develop proper bone growth. The concentration of calcium observed from the study area varied from 64 to 960 mg/l during pre-monsoon (June, 2013), 168 to 320 mg/l during monsoon (Oct. 2013) and 36 to 208 mg/l during post-monsoon (Jan. 2014) (Table 2). The results revealed that the all the values are exceeding the limits of FAO (1 0 0 - 200 mg/l) for irrigation water quality except TW_1, TW_2 during pre-monsoon (June), TW_2, TW_4, TW_5, TW_7, TW_8, TW_{10} and TW_{11} during monsoon (Oct.) and it was found that during post-monsoon (Jan.) the values were under permissible limits except TW_9 and TW_{13}. High values of the calcium and magnesium may also due to the seepage of effluent and domestic waste or due to cationic exchange with sodium, however low values do not mean that it is not influenced by the pollutants but it might be due the reverse cationic exchange with sodium (Balaji *et al.*, 2013). The higher value is mainly attributed due to the abundant availability of lime stone in the area. Consequently more solubility of calcium ions is present. These results are in agreement with the findings of Ananthakrishnan *et al.* (2012).

Magnesium is an essential ion for functioning of cells in enzyme activation, but at higher concentration, it is considered as laxative agent. The magnesium concentration of groundwater samples in the study area varied from 43 to 518 mg/l during pre-monsoon (June 2013), 48 to 250 mg/l during monsoon (Oct. 2013) and 62 to 168 mg/l during post-monsoon (Jan. 2014), respectively (Table 2). The results of magnesium revealed that the all the samples were exceeding the permissible limits of FAO (6-24 mg/l) .The concentration of magnesium may be due the dissolution of magnesium calcite, gypsum and dolomite. These results are in agreement with the findings of Ananthakrishnan *et al.* (2012).

The concentration of carbonates observed from the study area varied from101 to 370 mg/l during pre-monsoon (June, 2013) and 34 to 202 mg/l during monsoon (Oct. 2013), 101 to 235 mg/l post-monsoon (Jan. 2014) and concentration of bicarbonates varied from 209 to 592 mg/l pre-monsoon (June 2013), 116.6 to 563.8 mg/l during monsoon (Oct. 2013) and 62 to 296 mg/l post-monsoon (Jan. 2014), respectively (Table 3). All the samples in the study area for carbonates are exceeding the permissible limits of FAO (<50 mg/l) standards for irrigation except TW_1, TW_{12} and TW_{13} in monsoon and for bicarbonates all the samples were exceeding the permissible limits except TW_1, TW_4, TW_8, TW_{12} and TW_{13} in monsoon and all the values are within the permissible limits in post-monsoon season except TW_3 and TW_{13}. High alkalinity in natural waters will favor of producers such as algae and phytoplankton groups. These results are in agreement with the findings of Latha *et al.* (2012).

Nitrogen in groundwater is mainly derived from organic industrial effluents, fertilizer or nitrogen fixing bacteria, leaching of animal dung, sewage and septic tanks through soil and water matrix to groundwater. It causes blue baby syndrome called methemoglobinemia, which is an often fatal disease in infants of less than four months old. The concentration of nitrate of groundwater samples in the study area varied from 2.2 to 10.6

Table 2. Measured groundwater cationic concentrations (Na^+, K^+, $Ca^{++}$and Mg^{++}) during the water year 2013-14

Well No. (Location)	cationic concentrations (mg/l)											
	Pre-monsoon				Monsoon				Post-monsoon			
	Na	K	Ca	Mg	Na	K	Ca	Mg	Na	K	Ca	Mg
TW_1	194	0.3	64	72	192	0.4	224	110	44	0.5	72	62
TW_2	185	0.3	120	43	205	0.9	176	58	2	0.5	136	29
TW_3	119	0.3	296	58	120	0.4	248	77	152	0.6	80	77
TW_4	158	0.3	440	72	159	0.5	168	120	187	0.5	88	62
TW_5	151	0.4	504	125	130	0.4	196	149	139	0.5	128	101
TW_6	210	0.3	568	154	209	0.4	208	134	207	0.3	160	120
TW_7	172	0.3	640	259	174	0.5	168	134	172	0.2	96	77
TW_8	137	0.4	720	331	144	0.4	192	125	163	1.2	120	168
TW_9	64	0.9	824	418	92	1.0	320	250	100	1.5	208	106
TW_{10}	115	5.5	960	518	230	0.4	152	130	115	14.5	80	96
TW_{11}	178	0.2	412	182	178	0.5	200	130	210	0.6	120	144
TW_{12}	212	3.9	484	175	73	0.6	296	130	186	2.0	36	149
TW_{13}	184	0.3	520	211	69	0.4	296	48	60	1.1	208	67

Table 3. Measured groundwater anionic concentrations (CO_3^-, HCO_3^- and NO_3^-) during the water year 2013-14

Well No. (Location)	anionic concentrations (mg/l)								
	Pre-monsoon			Monsoon			Post-monsoon		
	CO_3^-	HCO_3^-	NO_3^-	CO_3^-	HCO_3^-	NO_3^-	CO_3^-	HCO_3^-	NO_3^-
TW_1	336	505	4.5	34	116.6	4.8	235	87	5.0
TW_2	370	296	2.2	202	563.8	2.9	235	0	2.2
TW_3	269	296	3.9	101	187.9	3.9	101	296	3.4
TW_4	302	278	3.4	67	153.1	4.1	202	70	2.8
TW_5	235	383	7.8	101	245.3	3.6	218	62	2.5
TW_6	202	592	10.6	134	355.0	5.3	235	71	2.8
TW_7	370	209	7.3	168	356.7	5.9	227	86	2.9
TW_8	235	296	6.7	67	146.2	7.1	202	139	2.2
TW_9	168	278	9.0	101	276.7	6.3	134	70	2.2
TW_{10}	101	348	10.6	101	240.1	5.9	134	139	1.1
TW_{11}	218	305	8.5	134	320.2	6.1	202	0	2.8
TW_{12}	227	374	7.8	34	83.5	8.1	210	70	3.4
TW_{13}	260	252	3.6	42	76.6	4.9	101	244	1.7

mg/l, 2.9 to 8.1 mg/l and 1.1 to 5 mg/l during pre-monsoon (June 2013), monsoon (October 2013) and post-monsoon (Jan. 2014), respectively (Table.3).

The concentration of nitrate in all the samples were within the permissible limits (50 mg/l) as prescribed by FAO standards for irrigation water quality, groundwater could be used for irrigation purpose in the study area. The presence of nitrates indicates the groundwater contamination through poor sanitation work allowing the percolation process. These results are in agreement with the findings of Priya and Prakash (2012).

The F^- concentration in groundwater depends upon the degree of weathering and leaching of fluoride from rocks and soils and has stated that the higher intake of $F^{''}$ may change the metabolic activities of soft tissues (thyroid, reproductive organs, brain, liver, and kidney) have reported that the $F^{''}$ concentration in marginal part of placenta in women has high plasma $F^{''}$ concentration. The $F^{''}$ concentration in the groundwater samples of the study area varied between 0.9 to 1.7 mg/l, 0.8 to 1.7 mg/l and 0.9 to 2.3 mg/l during pre-monsoon (June 2013), monsoon (Oct. 2013) and post-monsoon (Jan. 2014), respectively (Table 4). All the estimated values were found within the permissible limits (1-1.5 mg/l) as prescribed by FAO standards for irrigation water quality. Water could be used for irrigation purpose except TW_2, TW6 and TW_{11} in pre-monsoon, TW_2, TW_6 and TW_{10} in monsoon and TW_1, TW_2, TW_3, TW_4, TW_5, TW_6 and TW_{11}, in post-monsoon respectively, in all the sampling stations of the study area.

The concentration of fluoride in water was not uniform in the fluorotic areas. This may be due to the difference in the presence and accessibility of fluoride bearing minerals to the circulating water. The area is devoid of hard rocks and hence the possibility of a source could be the fluoride bearing minerals (Anita and Umayoru, 2013). Uneven distribution of fluoride in the groundwater was due to uneven distribution of fluoride containing minerals in the rocks. Fluoride concentration in natural waters depends on various factors such as temperature, pH, solubility of fluorine-bearing minerals, anion exchange capacity of aquifer materials (OH– for F–), and the nature of geological formations drained by water and contact time of water with a particular formation. These results are in agreement with the findings of Mukul and Shalu (2005).

Generally, chloride is considered as the important inorganic ions, which deteriorate the quality of drinking water at larger extent. For example, the Cl^- plays an important role in balancing level of electrolytes in blood plasma, but higher concentration can develop hypertension, risk of stroke, left ventricular hypertrophy, osteoporosis, rental stones, and asthma. Chloride ion is a predominant natural form of chlorine and is extremely soluble in water. The major sources of chloride in natural water are sedimentary rocks particularly evaporates. Igneous rocks contribute only a fraction of total chloride. The Cl^- concentration of groundwater samples in the study area during pre-monsoon (June 2013), monsoon (Oct. 2013) and post-monsoon (Jan. 2013) ranged from 210 to 350 mg/l, 210 to 350 mg/l and 315 to 525 mg/l, respectively (Table 4). All the samples for chloride were within the permissible limit of FAO standards (250 mg/l) for irrigation water quality except TW_1, TW_8, TW_9, TW_{10} and TW_{11} during pre-monsoon, TW_2, TW_5, TW_7, TW_8, TW_9, TW_{10} and TW_{12} during monsoon and all the samples were exceeding the permissible limits during post-monsoon season. Excess chloride may be attributed to the seepage of domestic effluents (Suresh and Kottureshwar, 2009). Chloride concentration imparts salty taste and higher value produces laxative effect on consumers. These results are in agreement with the findings of Basavaraddi *et al.* (2012).

The sulphate content in the atmosphere precipitation is only about 2 ppm, but a wide range in sulphate content in ground water is made possible through reduction, precipitation, solution and concentration. The primary mineral sources of sulphate ions include evaporate minerals such as calcium, gypsum and sulphates of magnesium and sodium. The values of sulphate varied from 4.9 to 10.6 mg/l during pre-monsoon (June 2013), 4.7 to 9.5 mg/l during monsoon (Oct. 2013) and 0.4 to 7.4 mg/l post-monsoon (Jan. 2014) (Table 4). The concentration of sulphate in groundwater was found to be within the permissible limits as prescribed by FAO (500 mg/l) standards for irrigation water quality and water could be used for irrigation purpose.

The periodical analysis of groundwater samples collected from the representative tube wells located in the study area

Table 4. Measured groundwater anionic concentrations (F^-, Cl^- and SO_4^{2-}) during the water year 2013-14

Well No. (Location)	anionic concentrations (mg/l)								
	Pre-monsoon			Monsoon			Post-monsoon		
	F^-	Cl^-	SO_4^{2-}	F^-	Cl^-	SO_4^{2-}	F^-	Cl^-	SO_4^{2-}
TW_1	1.5	315	4.9	1.5	210	4.7	1.8	490	3.8
TW_2	1.6	210	8.6	1.6	350	8.0	1.8	385	5.7
TW_3	1.3	210	10.2	1.3	245	9.5	1.6	350	6.2
TW_4	1.3	245	10.4	1.4	210	9.2	1.7	525	3.8
TW_5	1.4	245	10.0	1.5	280	9.5	1.7	385	7.4
TW_6	1.7	210	10.0	1.6	245	8.8	1.7	455	7.7
TW_7	1.6	245	8.2	1.5	280	7.6	1.2	315	7.5
TW_8	1.2	280	8.2	1.3	315	6.5	1.7	385	4.8
TW_9	0.9	280	10.6	0.8	350	8.5	1.1	455	4.0
TW_{10}	1.0	350	10.5	1.7	280	6.8	1.1	525	4.8
TW_{11}	1.7	280	9.2	1.6	210	6.8	2.3	350	4.6
TW_{12}	1.2	245	9.8	0.8	315	7.6	1.0	385	6.1
TW_{13}	1.6	210	10.3	0.8	245	5.5	0.9	350	0.4

revealed that the parameters such as pH (7-8.5), EC (0.83-1.32 dS/m), sodium (2-210 mg/l), potassium (0.3-14.5 mg/l), nitrate (1.1-10.6 mg/l)and sulphates (0.4 - 10.6 mg/l) were within the permissible limits and there are no abnormal changes during the study barring minor variation in few wells during pre-monsoon. The parameters such as SAR, calcium (36-960 mg/l), magnesium (43-518 mg/l), carbonates (34-370 mg/l), fuoride (0.8-2.3 mg/l) and bicarbonates (62-592 mg/l) varied rapidly during pre-monsoon (June 2013) monsoon (Oct. 2013) and post-monsoon (Jan. 2014). Therefore, tube well water for irrigation parameters needs to be monitored on continuous basis to maintain the soil health in the study area.

References

Ahamed, J. A., Loganathan, K. and Ananthakrishnan, S., 2013, Hydro-chemical investigation of groundwater in some parts of Thanthoni and Karur Region, Tamilnadu, India. *Int. J. Sci. & Tech. Res.,* 2(4): 110- 112.

Ananthakrishnan, S., Loganathan, K. and Jafarahamed, A., 2012, Study on ground water quality and its suitability or drinking purpose in Alathur block -Perambalur district. *Archives of Appl. Sci. Res.,* 4(3): 1332-1338.

Anita, A. J. R. and Umayoru, B. V., 2013, Comparison of physicochemical parameters in the ground water samples of the fluorotic and nonfluorotic areas of Agastheeswaram Union, South India. *J. Environ. Sci. Toxicol. and Food Tech.,* 4(3): 27-34.

Balaji, B. P., Nandakumar, R., Dineshkumar, S., Ananth, S., Shenbega Devi, A., Jayalakshmi, T., Raju, P., Thiyagarajan, M. and Santhanam, P., 2013, Seasonal variations in physic-chemical characteristics of pond and groundwater of Tiruchirapalli, India. *J .Environ. Bio.,* 34(3): 529-537.

Basavaraddi, S. B., Heena, K. and Puttaiah, E.T., 2012, Seasonal variations of ground water quality and its suitability for drinking in and around Tiptur town, Tumkur district, Karnataka, India: A WQI approach. *Int. J. Comput. Eng. Res.,* 2(2): 562-567.

Latha, H. T., Pradeep, K. G. N., Lakshminarayana, P. and Anil, A., 2012, Assessment of groundwater quality index for Upper Pincha Basin, Chittoor District, Andhra Pradesh, India using GIS. *Int. J. Sci. and Eng. Res.,* 3(7): 1-8.

Mohamed, S. K. M. and Zahir, H. A., 2012, Monitoring the quality of groundwater on the bank of Cooum river at Chennai city, Tamil Nadu, India. *Adv. in Appl. Sci. Res.,* 3(6): 3587-3592.

Mukul, B. and Shalu, A., 2005, Potable groundwater quality in some villages of Haryana, India: Focus on fluoride. *J. Environ. Biol.,* 28(2): 291-294.

Priya, P. L. and Prakash, D. R., 2012, Studies on the groundwater quality from six villages of Hatkanangale taluka, Kolhapur district. *Int. J. Appl. Sci. and Eng. Res.,* 1(2): 224-231.

Suresh, T. and Kottureshwara, N. M., 2009, Quality of groundwater in selected areas of Sandur taluk in Karnataka state, India. *Rasayan J. Chem.,* 2(2): 350-360.