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Physico Chemical Assessment and Comparison of Quality of Underground Water for Drinking Purpose at Periodic Interval in the Village of Srikurmam, Gara Mandal in Srikakulam District, Andhra Pradesh, India

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Safe drinking water is essential to the protection of public health and well-being of citizens. Clean safe and adequate fresh water is vital to the survival of all living organisms. Drinking water affects the health of human beings due to the presence of various chemical constituents. Therefore, every person should have required the minimum knowledge of quality of drinking water.

Ground water is the one of the major sources of water for drinking, agricultural and industrial needs. The subject of the quality of water in village of Srikurmam in Gara mandal of Srikakulam District, Andhra Pradesh is taken up for the study. An attempt is made to investigate the physico-chemical parameters of ground water on seasonal base and its comparison. The results in this presentation are reported and comparison on the seasonal base like June 2011, July 2012 , July 2013 and in the month of May 2014. The results obtained are related to electrical conductivity, pH, Turbidity, Total Dissolved Solids, Total Hardness, Calcium and Magnesium Hardness, Chlorides, Alkalinity, Fluorides, Nitrites, Phosphates, Phenol, Metals like Sodium, Potassium, Iron, Zinc, Cadmium, Cobalt, Nickel, Lead and Copper. The results obtained are compared with standards of WHO and BIS and assessing the quality of ground water for drinking purposes through Water Quality Index (WQI). Finally, the results indicate that the water at Srikurmam is not fit for drinking without using a standard purification method.

Key words: Quality of underground water, Srikurmam, Srikakulam and Chemical constituents.

INTRODUCTION

Water is a natural resource that sustains the necessary needs of all living creatures. It is not only for drinking and it plays a vital role in various sectors as in the form of an essential Engineering material. It is required for sustaining all forms of life, food production, economic development of industry and agriculture

The main resource of fresh water is the groundwater[1], which is commonly used for domestic, irrigation and industrial purposes. Ground water is the major source of drinking water in both urban and rural India. It is an important source of drinking water, but now a days, it is polluted in most areas due to increased human population, growth of industrial activities, dumping of industrial waste, improper disposal of garbage, use of fertilizers in agriculture and manmade activities[2]. Physical, chemical and biological characteristics determine the quality of water. Hence, it becomes essential to ensure the quality of groundwater to utilize it for various purposes.

The domestic, agricultural activities mostly depend on the groundwater in majority areas, and hence it is known to the importance of groundwater quality[3-5]. The quality of water and its environment is subjective to the geologic formation of an area

and mostly, the groundwater contains more mineral contents than the surface water. It is for this reason that the groundwater movement is slow and hence, longer contacts time with the sediments and the hydrologic conditions have a significant role[6] in the change of groundwater quality over a period.

The monitoring of water quality is one of the major tools for sustainable development and provides important information for water management[7]. The quality of water is vital concern for humanity since it is directly linked with human welfare. Therefore, monitoring the quality of water is one of the essential issues of drinking water management[8]. The quality of underground water in Srikurmam, Gara Mandal of Srikakulam District, Andhra Pradesh is observed closely and continously at periodic interval. Thus, in this research work an attempt has been made to assess the physical and chemical parameters of ground water at Srikurmam.

EXPERIMENTAL

Study area

Srikurmam village is located approximately 13 kilometers east of Srikakulam town near Bay of Bengal and is in the Gara Mandal of Srikakulam District, Andhra Pradesh, India. Srikurmam is located at latitude of 18° 16' N, longitude of 84° 1' E and an altitude of 17 meters (59 feet).

Water sampling

The groundwater samples are collected as per the standard manner[4] in the month of June 2011, July 2012, July 2013 and of May 2014. After each sample is collected, they are analyzed immediately for various parameters or preserved safely by taking care with suitable standard precautionary methods to avoid deterioration/alteration. All the water samples are collected in 2 Litres plastic bottles that were washed and double rinsed with distilled water before sampling. The list of sample collection places in Srikurmam is given in the Table 1.

Instruments used

The following instruments are used to analyze various constituents present in ground water samples. Atomic Absorption Spectrometer (AAS) (PerkinElmer 400), UV-Visible Double beam Spectrophotometer(Model AU – 2701, Systronics), Digital pH meter (Model 335, Systronics), Nefleometer (Model 132, Systronics), Digital Conductometer(Model 306, Systronics), Micro processor based bunch P^H / Ion meter, Cyber scan 2100, Eutech instruments (USA) with fluoride sensitive electrode.

Chemicals used

All the Chemicals used are of Analytical Reagent Grade (Merck, BDH and Qualigens) and the solutions are prepared by using triply distilled water and, water without carbon dioxide is used when required. The following solutions are used for analysis and wherever standard solutions are required, for this the standardization methods[9] are followed. The following list of chemicals are used in this research work such as Potassium hydrogen phthalate, Potassium hydrogen phosphate, Potassium dihydrogen phosphate, Calcium Carbonate, EDTA, Na_2CO_3, HCl, NaCl, $AgNO_3$, Sodium oxalate, Potassium permanganate, Ferrous Ammonium Sulphate, $K_2Cr_2O_7$, APDC (Ammonium 1- pyrolidiene dicarbomate), MIBK (Methyl Isobutyl ketone) and concentrated HNO_3, Hypo, 10 % $BaCl_2$, 10% KI , 1000 ppm of fluoride and Nitrite solution, stock phenol solution, 4-aminoantipyrine, Potassium ferricyanine, chloroform, Borax buffer, Ammonium chloride-ammonium hydroxide buffer solution, TISAB Buffer, $AgNO_3$ – Nitric acid reagent, Vanadate – molybdate reagent, 0.5% Sulphanalamide reagent and indicators of phenolphthalein, methyl orange, EBT, Muroxide, K_2CrO_4 and 1% Starch.

Procedure of assessment of various constituents in water

For estimation of various constituents present in the groundwater like pH, Electrical Conductivity(EC), Turbidity, Total Dissolved Solids(TDS), Alkalinity, Total Hardness(TH), Ca and Mg Hardness, Fluoride(F^-), Chloride(Cl^-), Nitrite(NO_2^-), Sulphate, Phosphate, Phenol & metals like Sodium(Na), Potassium(K), Iron(Fe), Zinc(Zn), Cadmium(Cd), Nickel(Ni), Cobalt(Co) and Lead(Pb) are estimated by following standard methods[10].

RESULTS AND DISCUSSIONS

Based on the results obtained in Periodic interval [Table 2, 3 and 3(a)] the analyzed parameters are compared with the values of WHO[11] and BIS[12]

to know the quality of water. In all periodic intervals (June 2011, July 2012, July 2013 and in the month of May 2014) all the parameters are analysed and compared. It is identified that they maintains almost nearer values in the respective interval times. Many parameters do not match desired limits of potable parameters as per standard guidelines of WHO[11] and BIS[12]. From the obtained values, graphs (Figure1, 2, 3 and 4) are drawn for some of the parameters with their desirable limits for its comparison.

Here the Water Quality Index (WQI)[13] values has been calculated and reported based on the results obtained in the samples for the year 2014 to evaluate the suitability of ground water quality for potable purpose. The same procedure was also implemented to the samples that are collected in the years 2011, 2012 and 2013. For calculation of WQI, the following four steps have been taken into account. In the first step, each of the nine analyzed parameters has been assigned a weight (wi) according to its relative importance in the overall quality of water for drinking purposes Table 4. In the second step, the relative weight (Wi) is calculated as per the established[13-15] method as follows.

Relative weight (Wi) = $\frac{wi}{\sum_{i=1}^{n} wi}$,

Here 'Wi' is the relative weight, 'wi' is the weight of each parameter and 'n' is the number of parameters.

Table 1: List of sample collection sites

S no.	Location of sample	Source
1	Brahmin Street	Bore Water
2	Kurmanatha Temple opposite	Bore Water
3	Vyshnavi Street	Bore Water
4	Near Bus Stand	Bore Water
5	Secondary Government School	Bore Water
6	Karnala Street	Bore Water
7	Karnala Street	Well Water
8	Kandra Street	Bore Water
9	Market Street	Bore Water
10	Devara Street	Bore Water
11	Segidipeta	Bore Water
12	Indiranagar colony	Bore Water
13	Velama Street	Well Water
14	Panchayati office	Well Water
15	Bankers colony(Pratap house)	Bore Water

In the third step a quality rating scale (Qi) for each parameter is calculated by following equation; Qi = (Ci/Si) × 100, here 'Ci' is the concentration of each chemical parameter in each water sample in mg/L and 'Si' is the standard value according to the Guide lines of WHO[16] per each chemical parameter [Table 4]. In the fourth step the sub index (Sli) of each chemical parameter is estimated by using the equation

Sli = Wi × Qi. The overall Water Quality Index was calculated by adding together each sub index values of each water samples as follows;

WQI = $\sum Sli$.

Based on the results of obtained [Table 5] Water Quality Index from the samples and these values are compared with the standard [Table 5] WQI values[17, 18] for human consumption. It clearly

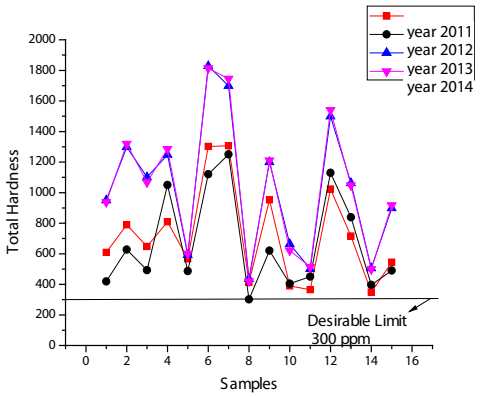

Fig. 1: Plot of Hardness Vs samples

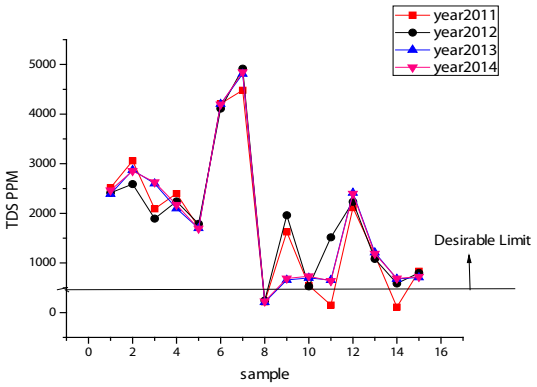

Fig. 2: Plot of Total Dissolved Solids Vs samples

Table. 2: Values of various constituents present in the water samples (June 2011 & 2012)

S.no	pH	EC	Turbidity	TDS	Alkalinity	TH	Ca	Mg	F^-	Cl^-	NO_2^-	SO_4^{2-}	PO_4^{2-}	Phenol	Na	K
Years	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	11	11	11	11
	(2012)	(2012)	(2012)	(2012)	(2012)	(2012)	(2012)	(2012)	(2012)	(2012)	(2012)	(2012)	(12)	(12)	(12)	(12)
1	7.18	4580	0.08	2514	948	609	92	92	0.23	407	2.78	689	21		125	21
	(7.40)	(3070)	(0.11)	(2412)	(1090)	(419)	(91)	(66)	(0.52)	(618)	(1.89)	(571)	(22)		(120)	(25)
2	7.11	4360	0.12	3060	609	790	136	108	0.39	417	0.04	598	15		97	17
	(7.07)	(3250)	(0.16)	(2589)	(781)	(628)	(140)	(89)	(0.65)	(704)	(0.02)	(307)	(14)		(101)	(19)
3	7.16	4160	0.06	2092	590	647	132	76	0.47	359	0.016	521	21		93	18
	(7.11)	(3180)	(0.09)	(1894)	(732)	(493)	(97)	(69)	(0.63)	(568)	(0.01)	(321)	(19)		(102)	(21)
4	7.08	3360	0.21	2400	490	809	158	99	0.36	363	2.79	370	18		63	14
	(7.61)	(3290)	(0.26)	(2240)	(401)	(1050)	(81)	(92)	(0.77)	(614)	(2.23)	(175)	(15)		(69)	(9)
5	7.19	3540	0.02	1719	339	567	128	60	0.22	304	0.02	440	16		78	10
	(7.18)	(3260)	(0.32)	(1788)	(368)	(487)	(255)	(87)	(0.20)	(430)	(0.02)	(455)	(17)		(69)	(14)
6	7.01	5540	0.10	4208	157	1302	104	263	0.22	780	0.49	353	24		131	21
	(7.04)	(4940)	(0.16)	(4110)	(946)	(1120)	(163)	(116)	(0.67)	(818)	(0.28)	(423)	(21)		(139)	(23)
7	7.13	5890	0.09	4482	490	1307	229	176	0.44	850	0.29	407	23		165	19
	(7.14)	(5440)	(0.12)	(4916)	(710)	(1250)	(186)	(108)	(0.61)	(733)	(0.21)	(323)	(22)		(178)	(26)
8	7.29	1030	0.05	216	387	414	151	89	0.53	76	Nil	177	16		33	9
	(6.98)	(1170)	(0.09)	(245)	(500)	(302)	(40)	(30)	(0.45)	(100)	(0.01)	(172)	(15)		(31)	(8)
9	7.18	2970	0.23	1627	442	953	152	88	0.68	367	0.046	517	19		99	7
	(7.09)	(2070)	(0.28)	(1961)	(649)	(620)	(109)	(79)	(0.87)	(409)	(0.02)	(258)	(18)		(87)	(10)
10	7.19	1120	0.04	546	339	390	91	39	0.68	87	0.046	161	14		24	9
	(7.17)	(1050)	(0.08)	(528)	(484)	(405)	(69)	(57)	(0.99)	(162)	(0.04)	(133)	(16)		(26)	(6)
11	7.12	1040	0.06	151	351	365	132	76	0.46	101	Nil	206	16		24	8
	(7.06)	(1020)	(0.09)	(1516)	(633)	(450)	(101)	(58)	(0.82)	(119)	(0.02)	(202)	(14)		(28)	(12)
12	7.03	2820	0.07	2114	460	1023	170	126	0.71	421	0.017	253	19		61	13
	(7.23)	(3100)	(0.06)	(2234)	(486)	(1130)	(201)	(178)	(0.81)	(375)	(0.02)	(266)	(18)		(72)	(14)
13	7.12	3180	0.13	1156	545	716	115	94	0.43	446	Nil	236	20		63	11
	(7.33)	(2960)	(0.18)	(1081)	(693)	(839)	(108)	(65)	(0.85)	(690)	(Nil)	(149)	(18)		(69)	(13)
14	7.38	0980	0.07	110	375	348	56	50	0.53	95	Nil	320	21		25	7
	(7.55)	(1010)	(0.04)	(588)	(467)	(369)	(45)	(37)	(0.87)	(121)	(Nil)	(482)	(19)		(20)	(9)
15	7.23	2280	0.03	835	333	544	110	65	0.79	198	0.080	402	16		47	11
	(7.25)	(2170)	(0.08)	(799)	(539)	(490)	(97)	(79)	(0.89)	(387)	(Nil)	(474)	(18)		(53)	(10)

Phenol constituent is not identified in any water samples

The 2012 values are given in parenthesis, except pH, EC and turbidity remaining parameters are all in mg/l

Table. 3: Values of various constituents present in the water samples (June 2013 & 2014)

S.no	pH	EC	Turbidity	TDS	Alkalinity	TH	Ca	Mg	F^-	Cl^-	NO_2^-	SO_4^{2-}	PO_4^{2-}	Phenol	Na	K
	2013	2013	2013	2013	2013	2013	2013	2013	2013	2013	2013	2013	13	13	13	13
	(2014)	(2014)	(2014)	(2014)	(2014)	(2014)	(2014)	(2014)	(2014)	(2014)	(2014)	(2014)	(14)	(14)	(14)	(14)
1	7.99	3980	0.11	2388	408	950	167	126	0.39	660	1.65	512	19		115	18
	(8.05)	(4001)	(0.13)	(2466)	(426)	(937)	(175)	(119)	(0.31)	(649)	(1.81)	(486)	(21)		(121)	(20)
2	8.09	4000	1.09	2872	356	1299	235	168	0.6	676	0.02	421	15		99	15
	(8.02)	(4100)	(1.03)	(2856)	(348)	(1320)	(240)	(174)	(0.52)	(682)	(0.04)	(398)	(17)		(103)	(16)
3	7.99	3998	0.39	2599	329	1102	201	120	0.51	569	0.02	351	16		91	14
	(7.95)	(4002)	(0.45)	(2626)	(340)	(1067)	(213)	(128)	(0.49)	(573)	(0.03)	(264)	(17)		(99)	(18)
4	7.78	3350	0.29	2099	285	1248	290	146	0.5	640	2.81	160	14		61	11
	(7.88)	(3380)	(0.3)	(2172)	(297)	(1286)	(282)	(139)	(0.46)	(633)	(2.09)	(105)	(13)		(66)	(10)
5	7.91	3350	0.18	1702	311	592	145	81	0.29	414	0.01	220	16		74	14
	(7.81)	(3460)	(0.2)	(1695)	(321)	(601)	(135)	(72)	(0.31)	(401)	(0.02)	(201)	(14)		(76)	(15)
6	7.63	5990	0.24	4204	351	1829	351	198	0.49	1095	0.51	183	18		136	22
	(7.50)	(5960)	(0.21)	(4195)	(334)	(1813)	(366)	(215)	(0.40)	(1048)	(0.53)	(177)	(16)		(146)	(26)
7	8.00	6580	0.5	4812	323	1698	329	221	0.61	942	0.31	81	19		178	21
	(8.09)	(6770)	(0.47)	(4844)	(315)	(1745)	(344)	(211)	(0.60)	(950)	(0.03)	(66)	(18)		(183)	(28)
8	8.00	1000	0.99	210	188	436	91	72	0.58	180	0.02	80	13		31	7
	(8.03)	(1005)	(1.07)	(225)	(192)	(420)	(84)	(49)	(0.61)	(187)	(Nil)	(78)	(11)		(29)	(9)
9	7.67	3040	2.74	659	278	1200	220	149	0.8	683	0.005	96	16		95	8
	(7.81)	(3130)	(2.9)	(687)	(291)	(1211)	(227)	(154)	(0.76)	(673)	(Nil)	(92)	(13)		(93)	(11)
10	7.59	1120	1.13	700	245	664	100	80	0.79	169	0.021	278	14		21	6
	(7.87)	(1180)	(1.26)	(732)	(232)	(622)	(106)	(85)	(0.81)	(178)	(0.031)	(282)	(12)		(24)	(8)
11	7.92	960	0.4	656	212	501	101	49	0.46	172	0.004	269	13		19	9
	(8.13)	(980)	(0.46)	(637)	(218)	(513)	(112)	(55)	(0.54)	(178)	(0.002)	(269)	(12)		(23)	(11)
12	7.69	3480	3.69	2412	239	1499	278	187	0.79	787	0.01	240	15		59	11
	(7.87)	(3440)	(3.8)	(2395)	(245)	(1540)	(284)	(198)	(0.84)	(766)	(0.02)	(242)	(14)		(71)	(14)
13	7.91	3480	0.59	1213	299	1063	194	136	0.45	699	0.002	369	15		61	12
	(7.98)	(3590)	(0.63)	(1189)	(302)	(1047)	(202)	(129)	(0.48)	(707)	(0.021)	(370)	(16)		(66)	(11)
14	7.98	1190	0.64	679	191	506	111	63	0.51	245	0.002	294	17		22	5
	(8.09)	(1150)	(0.6)	(689)	(199)	(499)	(106)	(56)	(0.52)	(230)	(0.022)	(294)	(15)		(18)	(7)
15	7.99	2000	0.58	708	229	898	152	131	0.84	401	0.005	311	16		45	10
	(8.06)	(2020)	(0.61)	(723)	(240)	(917)	(139)	(136)	(0.79)	(383)	(Nil)	(305)	(14)		(51)	(8)

Phenol constituent is not identified in any water samples

The 2014 values are given in parenthesis, except pH, EC and turbidity remaining parameters are all in mg/l

Table 3(a):Values of metal constituents present in the water samples in the seasons of years of 2011, 2012, 2013 and 2014.

	Iron (Fe) (in10^{-2}) mg/l				Copper (Cu) (in10^{-2}) mg/l				Zinc (Zn) (in10^{-2}) mg/l				Cadmium (Cd) (in10^{-2}) mg/l			
Year S.no	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014
1	4.5	3.5	4.1	4.9	1.5	1.0	1.1	1.6	6.3	7.3	8.5	8.7	0.8	0.4	0.3	0.6
2	5.2	4.3	3.9	5.6	1.4	4.3	4.4	1.3	6.6	6.6	7.0	7.5	0.7	0.41	0.21	0.6
3	4.1	5.2	4.9	3.9	2.1	2.4	2.1	2.0	20.2	23.2	21.3	23.3	0.7	0.54	0.49	0.6
4	17.3	18.1	17.8	16.3	19	3.2	2.9	1.9	16.6	17.4	16.7	19.5	0.7	0.71	0.66	0.6
5	12.1	12.9	14.0	11.8	4.6	4.8	5.9	4.9	5.4	6.2	5.9	7.8	0.7	0.6	0.4	0.6
6	3.7	3.2	2.6	3.4	2.2	2.9	3.1	2.4	3.3	4.1	3.8	4.9	0.7	0.65	0.69	0.7
7	3.4	2.9	2.8	3.4	1.3	1.2	1.6	1.1	5.9	6.1	5.9	6.5	0.7	0.67	0.71	0.7
8	3.8	4.1	3.8	3.9	1.6	1.8	2.0	1.6	4.3	4.7	5.0	5.8	0.7	0.8	0.6	0.7
9	3.0	3.7	3.7	3.1	1.3	1.8	1.5	1.2	13	13.4	14.2	14.8	0.7	0.9	0.65	0.6
10	6.4	7.2	7.2	6.5	1.3	1.7	1.8	1.3	3.5	3.9	4.4	4.7	0.7	0.7	0.4	0.7
11	3.1	3.0	3.1	2.1	3.9	4.1	3.9	3.6	3.8	4.1	4.8	5.2	0.7	0.8	0.6	0.7
12	11.1	12.3	12.8	9.9	3.7	4.5	4.0	3.9	3.8	3.9	4.1	4.6	0.7	0.6	0.6	0.6
13	8.2	6.5	6.5	7.9	5.4	6.1	6.5	5.6	18.4	17.9	16.2	18.5	1.5	1.7	1.9	1.4
14	10.6	17.8	16.1	10.4	2.8	2.8	3.0	2.8	10.3	18.7	17.3	15.8	1.5	1.3	1.6	1.4
15	22.4	22.8	21.3	20.1	1.6	1.9	2.1	1.8	9.8	11.1	11.9	10.2	0.7	0.7	0.5	0.6

The metals like Nickel, Cobalt and lead in these water samples are present in the below detectable limits, so these values can be considered as negligible amounts.

indicates that the underground water at research sites in most of the areas in Srikurmam is not fit for drinking purposes without any purification. Therefore, based on the overall results the underground water at Srikurmam in almost all areas is not suitable for drinking.

Table. 4: Chemical Parameters, weight (wi), WHO Standards and calculated weight (Wi) for each Parameter

S.No	Chemical Parameter	Weight(wi)	WHO Standards(Si)	Relative weights (Wi)
1	TDS	5	500	0.16666
2	Total Hardness	5	300	0.16666
3	Chloride	4	250	0.13333
4	sulphate	3	250	0.1
5	Calcium	2	75	0.06666
6	Magnesium	2	50	0.06666
7	Fluoride	4	1.5	0.13333
8	Sodium	4	200	0.13333
9	Pottasium	1	12	0.03333
		$\Sigma wi = 30$		

Table. 5: Water quality Index of each ground water sample at Srikurmam

S.No	TDS(Sli)	TH(Sli)	Cl^-(Sli)	SO_4^{2-}(Sli)	Ca^{2+} (Sli)	Mg^{2+}(Sli)	F^-(Sli)	Na^+(Sli)	K^+(Sli)	WQI
1	82.2	52.05	34.61	19.44	15.55	15.86	2.75	8.06	5.55	236.0
2	95.2	73.33	36.37	15.92	21.33	23.19	4.62	6.86	4.44	281.2
3	87.53	59.27	30.55	10.56	18.93	17.06	4.35	6.59	4.99	239.8
4	72.4	71.44	33.75	4.2	25.06	18.53	4.08	4.39	2.77	236.6
5	56.5	33.38	21.38	8.04	11.99	9.59	2.75	5.06	4.16	152.8
6	139.83	100.7	55.89	7.08	32.53	28.66	3.55	9.73	7.22	385.2
7	161.46	96.94	50.66	2.64	30.57	28.13	5.33	12.19	7.77	395.6
8	7.5	23.33	9.973	3.12	7.46	6.53	5.42	1.53	2.49	67.35
9	22.9	67.27	35.89	3.68	20.17	20.53	6.75	6.19	3.05	186.4
10	24.4	34.55	9.49	11.28	9.42	11.33	7.19	1.59	2.22	111.4
11	21.23	28.5	9.49	10.76	9.95	7.33	4.79	1.53	3.05	96.63
12	79.83	85.55	40.85	9.68	25.24	26.39	7.46	4.73	3.88	283.6
13	39.63	58.16	37.7	14.8	17.95	17.19	4.26	4.39	3.05	197.1
14	22.96	27.72	12.26	11.76	9.42	7.46	4.62	1.19	1.94	99.33
15	24.1	50.94	20.42	12.2	12.35	18.13	7.02	3.39	2.22	150.7

Standard WQI values for water to human consumption

WQI Range	Type of Water
< 50	Excellent Water
50.1 - 100	Good Water
100.1- 200	Poor Water
200.1 - 300	Very Poor Water
> 300.1	Unfit for Water

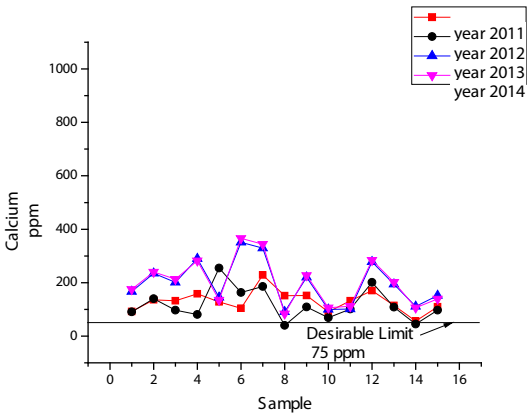

Fig. 3: Plot of Calcium content Vs samples

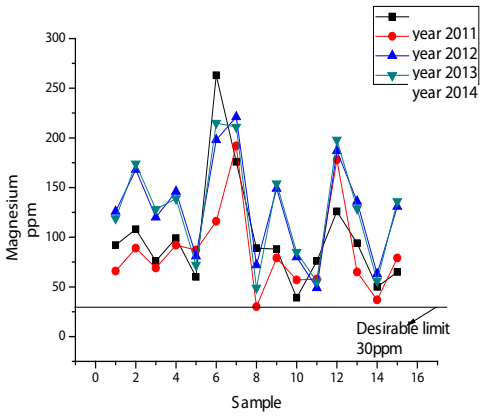

Fig. 4: Plot of Magnesium content Vs samples

Further, an attempt is made to know the possibility of removal of hardness from the samples by using a conventional method such as boiling. It is not helpful in any manner. This clearly indicates that the rate of decreasing of hardness is very less in the chosen samples and the underground water in Srikurmam has a characteristic property of more permanent hardness than temporary hardness. In addition, one more attempt is made to remove the excess amounts from the various constituents present in the water; the water is subjected to Reverse Osmosis (RO) process. After treatment by RO, the treated water samples are analyzed and the results obtained clearly indicate that maximum excess amounts are eliminated by RO technique; it indicates that the water in Srikurmam is treated to make it suitable for drinking. Hence, the overall results indicate that the water at Srikurmam is not fit for drinking without using an established purification method.

After thorough observations of the study area and physical chemical analysis of groundwater samples at Srikurmam, the causes of contamination of the ground water may be either because of seepage of sewage and sullage or of natural geological conditions. In addition to this, the wastewater from different sources such as kitchens, septic tanks and cesspits is discharged in to drainage canals. Unfortunately, the drainage canals are not properly constructed and maintained. As a result, there is an every possibility of seepage of sewage and sullage to the ground water and it will pollute the underground water in the areas under study.

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