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STUDY ON PHYSICO-CHEMICAL ANALYSIS OF GROUND WATER QUALITY AND LINEAR CORRELATION ANALYSIS OF, LINGAPALEM MANDAL, WEST GODAVARI DISTRICT, ANDHRAPRADESH, INDIA.

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ABSTRACT

The ground water quality is determined in Lingapalem Mandal which lays in the Northern part of West Godavari District of Andhra Pradesh where 19 water samples were collected from different villages and studied various physico-chemical parameter like pH, turbidity, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), Total alkalinity (TA) content of calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na), potassium (K), Iron (Fe), chloride (Cl^-), fluoride (F^-), sulphate (SO_4^{2-}), Nitrite (NO_2^-), DO, BOD, COD, were determined. The results were compared with ICMR and Indian standards of water quality. Statistical data and correlation coefficient matrix were also determined which gives hydro chemical relation among different chemical parameters.

Key words: Ground water quality, Lingapalem Mandal, ICMR Standards, Statistical data, correlation coefficient matrix.

Introduction

A systematic study is proposed to assess the quality of drinking water sources. In this perception, water samples were collected from different villages of Lingapalem Mandal. The study area is abundant with ground water and it is the only source for drinking and Irrigation. Ground water source is considered as the replenishable water source for domestic, agriculture and industrial activities in most of the world. It has certain inherent advantages over surface water. But its quality has damaged severely due to over exploitation of urban areas and improper measures of disposal. However, it is stressed that the quality of resources is important. Drinking water must be free from organisms like bacteria and virus. In addition to this, water also should be free from excess of minerals, fluoride, iron which produce adverse physiological effects. Hence, there is always a need for management of ground water quality. Groundwater chemistry depends on a number of factors, such as general geology, degree of chemical weathering of the various rock types, quality of recharge water and inputs from sources other than water rock interaction. Such factors and their interactions result in a complex groundwater quality. India is the largest user of groundwater in the world. In our country, more than 60 percent of the irrigation requirements and 85 percent of drinking water supplies are dependent on ground water. Every 8 seconds, a child dies from water related disease around the globe, 50 percent of people in developing countries suffer from one or more water related disease and 80 percent of diseases in the developing countries are caused by contaminated water. Ground water is a major source of drinking water in India and it is affected due to geo-genic contamination and anthropogenic pollution.

Study area: The West Godavari district is one of the 13 districts of Andhrapradesh. It occupies an area of approximately 7700 square kilometers. It has 46 Mandals out of which 24 are in the Upland Region. Geomorphologically the district can be divided into two major regions viz., alluvial deltaic region and upland areas. The deltaic region mostly constitutes black cotton soils and the upland areas are dominated by the red soils. The Study area of lingapalem Mandal consists of 19 panchayats and it lies between 16.88031 to 16.98490 Latitude and 81.02160 to 81.0090 Longitude respectively. A systematic study is proposed to assess the quality of ground water sources.



Figure1 –location of Andhra Pradesh in India



Figure 2- Location of west Godavari in Andhra Pradesh



Figure 3-Location of mandals in westgodavari district.



Figure 4- Location of Lingapalem mandal

Water sampling: In present investigation 19 water samples from Lingapalem mandal are collected. The water samples were collected in polythene bottles which were cleaned with acid water and hot water followed by rinsing twice with distilled water. The water samples were analyzed by using procedures of standard methods.

Objectives: To identify and map drinking water sources of Lingapalem Mandal in the west Godavari district. To assess the drinking water sources for their quality. To Suggest scientific strategies for proving safe drinking water , improved water quality management and drinking water resource sustainability.

Methodology: The pH was measured by using Eutech ion- 2700 PH meter and EC was measured in electrical conductivity meter 304. Total hardness, calcium, magnesium were measured by EDTA titration methods. Total alkalinity was determined by volumetrically. Sulphate was determined turbidmetric method using digital Nephelo turbidity meter 132 . Fluoride and chloride content in water was determined by using ion selectivity meter Eutech ion -2700. The Physico-chemical analysis was carried out according to standards methods. Iron, nitrite and phosphate were determined by spectrophotometer. DO, BOD, COD were determined using standard methods.

Table 1:Gps details of Lingapalem Mandal.

S.No	Sample	Village Name	GPS Details		Geology	Health	Landmark	Source
			Latitude & Longitude	Elevation (Ft)				
1	11:1:1S	Badrala	16.91881,81.10940	249	Red soil	Good	Village Starting Point	500
2	11:2:1S	Asannagudem	16.94918,81.10885	306	Red soil, Sand stones	Good	-	-
3	11:3:1S	Vemulapalli	16.94841,81.09776	284	Red soil, Black cotton soil	Body Pains	Z P High School	1200
4	11:4:1S	Ramanujapuram	16.94141,81.08135	307	Red loamy	Good		1500
5	11:5:1S	Rangapuram	16.94610,81.06880	321	Red loamy	Good	L M Colony Opposite Hanuman Temple	500
6	11:6:1S	Puppalarigudem	16.96805,81.07428	355	Red soil	Good		2000
7	11:6:2S	Puppalarigudem	16.96261,81.08046	329	Red loamy	Good	M P P School Road	500
8	11:7:1S	K Gokavaram	16.97551,81.06646	348	Red loamy	Viral Fevers		-
9	11:8:1D	Kottapalli	16.96401,81.03815	347	Red soil	Good	Pond	1000
10	11:9:1D	Singagudem	16.94891,81.00905	305	Red soil	Viral Fevers	Near Anganavadi Kendram	1500
11	11:10:1S	Lingapalem	16.94910,80.99711	450	Red loamy	Good	Friends Associated Charitable Trust	3000
12	11:11:1S	Yadavalli	16.96541,80.95268	154	Red sandy	Good	J L Satyanarayana Gari House	1000
13	11:12:1S	T Ch R Palem	16.93653,80.97413	290	Red soil, Gravel	Good	RachhaBanda	500
14	11:13:1S	Mattanagudem	16.92635,81.01081	236	Red soil	Good	Pond	-
15	11:14:1S	Dharamajigudem	16.89441,81.00426	245	Red soil	Good	S C Colony	1000
16	11:15:1S	Mulagalampadu	16.93493,81.05908	354	Red soil	Good	Ramalaya m Temple	700
17	11:16:1S	Rayannapalem	16.92943,81.05366	363	Red soil	Good	Bhogole Water Tank	-
18	11:17:1S	Kalaranigudem	16.88741,81.02756	276	Red soil	Good	Ramalaya m Temple	-
19	11:18:1S	Ayyaparajigudem	16.88031,81.02160	228	-	-	UttarBazar Tank	-

Table 2-Physico-chemical analysis of groundwater samples in Lingapalem Mandal in rainy season

S.No	Sample Code	pH	E.C	TDS	Turbidity	Alkalinity	Hardness	Sodium	Potassium	Calcium	Magnesium	Iron	Chloride	Fluoride	Nitrite	Sulphate	Phosphate	DO	COD	BOD
1	11:1:1S	8.14	1000	640	1	200	185	62	3.1	44	18.27	0	105	0.137	0	45	0	4.4	0	1.4
2	11:2:1S	8.17	1200	768	0	260	215	60	3.1	54	19.49	0	110	0.581	0	49	0	4.4	15	1.4
3	11:3:1S	8.29	900	576	1	296	165	54	4.5	46	12.18	0	59.2	0.722	0	18	0	4	4.8	1.2
4	11:4:1S	8.31	400	256	1	184	120	32	2.9	30	10.96	0	30.4	0.314	0	5	0	4.4	0	1.7
5	11:5:1S	8.31	700	448	0	260	145	87	5	44	8.53	0	131	0.259	0	28	0	5.2	1.6	1.8
6	11:6:1S	8.32	900	576	0	336	150	92	1.8	24	21.92	0	126	0.629	0	28	0	5.6	0	3.2
7	11:6:2S	8.77	1900	1216	0	494	165	135	8	46	12.18	0	165	1.91	0	142	0	4.8	0	2.4
8	11:7:1S	8.24	2300	1472	1	320	225	143	7.3	22	41.41	0	35	1.32	0	125	0	7.6	6.4	5
9	11:8:1D	8.32	2300	1472	1	522	365	129	10.2	12	81.61	0	336	1.62	0	70	0	4.4	19	2.4
10	11:9:1D	8.83	1100	704	0	598	160	134	6	48	9.74	0	80.4	1.84	0	75	0	4.8	12	2.8
11	11:10:1S	8.65	1100	704	1	410	215	97	7	28	35.32	0	130	1.42	0	54	0	4.4	9.6	2.4
12	11:11:1S	8.01	2600	1664	0	490	480	128	8.2	80	68.21	0	663	0.537	0	109	0	3.6	12	2
13	11:12:1S	8.43	2700	1728	1	580	470	174	8	54	81.61	0	576	1.21	0	128	0	4	1.6	1.2
14	11:13:1S	8.54	900	576	1	420	190	124	14.5	16	36.54	0	88.3	1.27	0	56	0	5.2	0	2.8
15	11:14:1S	8.11	1000	640	0	390	210	92	4.4	50	20.71	0	128	1.32	0	47	0	3.4	0	0.6
16	11:15:1S	8.08	2300	1472	1	462	390	117	6.7	80	46.28	0	565	0.332	0	50	0	4.8	0	2.8
17	11:16:1S	7.95	2100	1344	0	464	340	89	4	80	34.1	0	331	0.372	0	85	0	4	8	1.2
18	11:17:1S	8.29	900	576	2	362	205	90	2.5	40	25.58	0	86	0.648	0	48	0	4.8	17	2.4
19	11:18:1S	8.27	1400	896	0	432	260	77	2.6	44	36.54	0	161	1.23	0	80	0	4.8	1.4	4.1

Table 3-Physico-chemical analysis of groundwater samples in Lingapalem Mandal in winter season

S.No	Sample Code	pH	E.C	TDS	Turbidity	Alkalinity	Hardness	Sodium	Potassium	Calcium	Magnesium	Iron	Chloride	Fluoride	Nitrite	Sulphate	Phosphate	DO	COD	BOD
1	11:1:1S	7.9	800	512	0	196	185	13	4.5	42	19.49	0	95.3	0.433	0	61	0	4.4	36.8	2
2	11:2:1S	7.87	1000	640	0	274	200	26	3.3	40	24.36	0.023	201	0.647	0	53	0	4.4	56	2
3	11:3:1S	8.18	700	448	1	280	140	9	4.5	38	10.96	0	56.1	1.34	0	23	0	3.6	54.4	1.2
4	11:4:1S	8.02	500	320	1	180	110	3	4.5	26	10.96	0	43.1	0.877	0	10	0	3.6	70.4	0.8
5	11:5:1S	8.03	1000	640	0	294	190	54	10.8	38	23.14	0	188	1.04	0	64	0	4	57.6	2
6	11:6:1S	7.78	900	576	0	330	165	60	2.5	32	20.71	0	151	1.35	0	44	0	4.4	16	2.4
7	11:6:2S	7.77	1800	1152	0	464	155	130	6.8	42	12.18	0	135	1.86	0	130	0	4.6	11	2.2
8	11:7:1S	8.05	1500	960	0	448	240	95	10.1	40	34.1	0	416	1.94	0	109	0	4.8	27.2	3.2
9	11:8:1D	7.93	1100	704	0	400	215	40	11.4	40	28.01	0	168	2.52	0	88	0	4.4	19.2	1.6
10	11:9:1D	8.39	1200	768	0	564	170	114	13.8	22	28.01	0	117	3	0	109	0	4	16	1.6
11	11:10:1S	8.29	1200	768	0	440	225	66	13.8	24	40.19	0	351	2.45	0	71	0	4	24	1.6
12	11:11:1S	8.18	900	576	0	378	200	40	4.8	44	21.92	0	139	1.37	0	45	0	4	17.6	2.4
13	11:12:1S	8.04	2300	1470	0	550	340	171	16.2	38	59.68	0	1280	2.15	0	145	0	5.2	17.6	2.4
14	11:13:1S	8.15	1300	832	1	400	225	80	19.8	40	30.45	0	288	1.75	0	122	0	4.2	14.4	1.4
15	11:14:1S	8.04	1100	704	1	386	210	68	6.3	46	23.14	0	212	2.29	0	86	0	4	20.8	2
16	11:15:1S	7.65	1400	896	0	418	360	66	10.3	62	49.94	0	475	0.996	0	101	0	4.2	4	2.2
17	11:16:1S	7.64	1600	1024	0	438	340	66	8.6	60	46.28	0	568	0.842	0	98	0	4	11.7	1.6
18	11:17:1S	7.56	2200	1408	1	490	280	98	14	80	19.49	0	1081	1.09	0	104	0	4	11.7	1.8
19	11:18:1S	7.67	1200	768	1	440	195	66	5.1	42	21.92	0	235	2.32	0	88	0	4	11.4	1.8

Table 4-Physico-chemical analysis of groundwater samples in Lingapalem Mandal in summer season

S.No	Sample Code	pH	E.C	TDS	Turbidity	Alkalinity	Hardness	Sodium	Potassium	Calcium	Magnesium	Iron	Chloride	Fluoride	Nitrite	Sulphate	Phosphate	DO	COD	BOD
1	11:1:1S	7.17	700	448	0	210	225	55	1.4	34.07	34.1	0	62.5	0.361	0.029	22	0	5.6	0	4.4
2	11:2:1S	6.93	1100	704	0	296	170	80	2.8	44.09	14.62	0	155	0.384	0	43	0	4	0	2.8
3	11:3:1S	7.54	800	512	0	286	145	54	3.4	36.07	13.4	0	44.2	0.97	0	16	0	4.4	3.2	3.6
4	11:4:1S	7.22	600	384	0	214	110	45	4.2	26.05	10.96	0	42.1	0.525	0	5	0	4	6.4	3.8
5	11:5:1S	7.2	1500	960	0	350	225	92	8.5	52.1	23.14	0	237	0.699	0	89	0	4.4	6.4	2.4
6	11:6:1S	7.68	1000	640	0	316	195	66	2.8	38.04	18.27	0	102	1.08	0	44	0	4	3.2	2
7	11:6:2S	7	1100	704	0	360	125	84	2.1	30.06	12.18	0	139	0.97	0	42	0	3.6	9.6	2.4
8	11:7:1S	7.64	1000	640	0	330	135	84	2.1	34.07	12.18	0	144	0.96	0	41	0	4.4	11.2	1.2
9	11:8:1D	7.61	1200	760	0	400	235	79	9.9	42.08	31.67	0	148	1.74	0	110	0	4.4	3.2	1.2
10	11:9:1D	8.3	1300	832	0	600	125	116	4.2	20.04	18.27	0	101	2.06	0	88	0	4	6.4	4
11	11:10:1S	7.69	1400	896	0	650	370	92	4.8	32.06	70.64	0	168	1.8	0	63	0	4.4	4.8	0.4
12	11:11:1S	7.53	900	576	0	322	290	57	8.9	26.05	54.81	0	101	1.57	0	52	0	4.4	6.4	4.4
13	11:12:1S	7.44	2600	1664	0	568	180	134	11.1	44.09	65.77	0	439	1.56	0	131	0	2.4	4.8	1.2
14	11:13:1S	7.99	1400	896	0	332	195	112	13	32.06	28.01	0	216	1.2	0	123	0	4	9.6	4
15	11:14:1S	7.14	1400	896	0	408	225	86	5.9	46.09	26.8	0	179	1.72	0	83	0	4.8	11.2	0
16	11:15:1S	7.45	1500	960	0	304	300	84	8.5	58.12	37.76	0	350	0.431	0	74	0	3.6	4.8	3.6
17	11:16:1S	7.08	1700	1088	0	530	315	87	7.1	60.12	40.19	0	307	0.586	0	85	0	4.4	8	4.4
18	11:17:1S	7.42	1000	640	0	390	165	66	3.9	42.08	14.62	0	66.2	1.25	0	44	0	3.6	6.4	3.6
19	11:18:1S	7.63	1300	832	0	420	235	66	3.6	52.1	25.58	0	149	1.5	0	97	0	4	6.4	0.8

Degree of linear association between any two water quality parameters are measured by the simple correlation coefficient (r). This r value ranging from +1 to -1, if r value is greater than 0 indicates positive linear association, r value is less than 0 indicates negative linear association between any two water quality parameters. The correlation coefficient r value gives us information about sources of dissolved parameters, not only that it also gives information how one parameter vary with another parameters and gives possible combination of dissolved salts.

Table 5- correlation coefficient matrix of water quality parameters in rainy seasons.

	pH	E.C	TDS	Alkalinity	Hardness	Sodium	Potassium	Calcium	Magnesium	Chloride	Fluoride	Sulphate	DO	COD	BOD
pH	1														
E.C	-0.219	1													
TDS	-0.219	1	1												
Alkalinity	0.202	0.198	0.198	1											
Hardness	-0.402	0.868	0.868	0.089	1										
Sodium	0.335	0.721	0.721	0.271	0.544	1									
Potassium	0.346	0.411	0.411	0.302	0.335	0.67	1								
Calcium	-0.476	0.4	0.4	0.112	0.518	0.022	-0.225	1							
Magnesium	-0.214	0.798	0.798	0.044	0.889	0.622	0.511	0.069	1						
Chloride	-0.348	0.795	0.795	0.104	0.94	0.511	0.301	0.623	0.763	1					
Fluoride	0.716	0.213	0.213	0.459	-0.03	0.59	0.494	-0.397	0.177	-0.128	1				
Sulphate	0.186	0.791	0.791	0.223	0.517	0.786	0.423	0.203	0.494	0.432	0.534	1			
DO	0.195	0.01	0.01	-0.014	-0.32	0.229	0.097	-0.482	-0.116	-0.385	0.139	0.17	1		
COD	-0.016	0.201	0.201	0.353	0.244	0.104	0.047	-0.014	0.291	0.088	0.158	0.101	-0.099	1	
BOD	0.234	0.165	0.165	0.318	-0.085	0.31	0.156	-0.385	0.106	-0.168	0.326	0.295	0.826	0.011	1

Table 6- correlation coefficient matrix of water quality parameters in winter season.

	pH	E.C	TDS	Alkalinity	Hardness	Sodium	Potassium	Calcium	Magnesium	Chloride	Fluoride	Sulphate	DO	COD	BOD
pH	1														
E.C	-0.463	1													
TDS	-0.463	1	1												
Alkalinity	0.01	0.43	0.43	1											
Hardness	-0.388	0.268	0.268	0.527	1										
Sodium	-0.026	0.275	0.275	0.871	0.459	1									
Potassium	0.256	0.236	0.236	0.623	0.485	0.6	1								
Calcium	-0.734	0.619	0.619	0.193	0.617	0.113	0.091	1							
Magnesium	-0.029	-0.049	-0.049	0.541	0.871	0.506	0.552	0.15	1						
Chloride	-0.316	0.176	0.176	0.577	0.777	0.649	0.549	0.532	0.643	1					
Fluoride	0.458	0.031	0.031	0.677	-0.055	0.519	0.427	-0.404	0.182	0.025	1				
Sulphate	-0.154	0.441	0.441	0.822	0.599	0.879	0.692	0.293	0.569	0.588	0.455	1			
DO	-0.126	-0.06	-0.06	0.38	0.39	0.625	0.247	0	0.49	0.458	0.165	0.625	1		
COD	0.297	-0.515	-0.515	-0.766	-0.554	-0.612	-0.376	-0.399	-0.446	-0.386	-0.429	-0.706	-0.335	1	
BOD	-0.154	0.149	0.149	0.31	0.326	0.435	-0.056	0.166	0.306	0.26	0.048	0.375	0.717	-0.363	1

Table 7- correlation coefficient matrix of water quality parameters in summer season.

	pH	E.C	TDS	Alkalinity	Hardness	Sodium	Potassium	Calcium	Magnesium	Chloride	Fluoride	Sulphate	DO	COD	BOD
pH	1														
E.C	0.057	1													
TDS	0.056	1	1												
Alkalinity	0.364	0.665	0.664	1											
Hardness	-0.041	0.286	0.286	0.345	1										
Sodium	0.334	0.835	0.835	0.675	0.032	1									
Potassium	0.23	0.602	0.6	0.224	0.346	0.522	1								
Calcium	-0.421	0.471	0.47	0.058	0.441	0.084	0.232	1							
Magnesium	0.099	0.577	0.577	0.549	0.749	0.364	0.505	0.12	1						
Chloride	-0.102	0.916	0.916	0.42	0.382	0.708	0.632	0.611	0.542	1					
Fluoride	0.623	0.278	0.277	0.667	0.097	0.39	0.248	-0.328	0.341	-0.03	1				
Sulphate	0.347	0.81	0.808	0.573	0.298	0.78	0.762	0.359	0.439	0.703	0.491	1			
DO	-0.115	-0.589	-0.589	-0.318	0.249	-0.499	-0.324	-0.104	-0.131	-0.52	-0.1614	-0.365	1		
COD	0.121	0.165	0.166	0.198	-0.114	0.277	0.18	-0.045	-0.129	0.148	0.279	0.243	-0.108	1	
BOD	0.008	-0.335	-0.333	-0.363	-0.12	-0.247	0.041	-0.196	-0.182	-0.2	-0.4596	-0.314	0.119	-0.206	1

The correlation coefficient matrix for the results of different water quality parameters of samples collected in rainy, winter and summer seasons from lingapalem Mandal is presented in tables 5,6 and 7 respectively. The results in table 5 indicate that the Hardness is strongly correlated with TDS($r=0.868$).Magnesium is strongly correlated with Hardness ($r=0.899$)and Chloride is strongly correlated with Hardness and magnesium ($r=0.940,0.763$ respectively).

The correlation coefficient matrix in table 6 indicate that Calcium and Magnesium are correlated with TH ($r=0.617$ and $r=0.871$ respectively). Chloride is correlated with TH ($r=0.777$) it is also correlated with sodium($r=0.777$).

The results in table 6 show that Sodium, Chloride and Sulphate are strongly correlated with TDS($r=0.835,0.916,0.808$ respectively).Chloride is correlate with sodium ($r=0.708$).Sulphate is correlated with sodium and potassium($r=0.780,0.762$ respectively).

Table 8-Statistical data of Lingapalem Mandal in rainy season

PARAMETER	MIN	MAX	MEAN	STD
PH	7.95	8.83	8.317368	0.239487
EC	400	2700	1457.895	717.4924
TDS	256	1728	933.0526	459.1951
TURBIDITY	0	2	0.578947	0.606977
ALKILINITY	58	598	366.2105	134.2616
TH	120	480	245	109.7598
SODIUM	32	174	100.8421	35.76352
POTASSIUM	1.8	14.5	5.778947	3.185659
CALCIUM	12	80	44.31579	20.14683
MAGNESIUM	8.53	81.61	32.69368	22.92917
CHLORIDE	30.4	663	205.5947	194.3386
FLOURIDE	0.137	1.91	0.930053	0.563227
SULPHATE	5	142	65.36842	38.31479
DO	3.4	7.6	4.663158	0.899513
COD	0	19.2	5.852632	6.752725
BOD	0.6	5	2.252632	1.078254

Table 9-Statistical data of Lingapalem Mandal in winter season

PARAMETER	MIN	MAX	MEAN	STD
PH	7.56	8.39	7.954737	0.233247
EC	230	2200	1138.421	453.9244
TDS	147.2	1408	728.5895	290.5116
TURBIDITY	0	1	0.315789	0.477567
ALKILINITY	180	564	387.8947	106.246
TH	110	360	218.1579	68.43916
SODIUM	3	171	66.57895	42.58497
POTASSIUM	2.5	19.8	9.005263	4.899487
CALCIUM	22	80	41.89474	13.60512
MAGNESIUM	10.96	59.68	27.62789	13.27429
CHLORIDE	43.1	1280	326.2895	333.6532
FLOURIDE	0.433	3	1.592895	0.72723
SULPHATE	10	145	81.63158	36.30306

DO	3.6	5.2	4.2	0.38873
COD	4	70.4	26.2	19.26122
BOD	0.8	3.2	1.905263	0.526491

Table 10-Statistical data of Lingapalem Mandal in summer season

PARAMETER	MIN	MAX	MEAN	STD
PH	6.93	8.3	7.455789	0.34426
EC	600	2600	1236.842	441.2237
TDS	384	1664	791.1579	282.4262
TURBIDITY	0	0	0	0
ALKALINITY	210	650	383.4737	123.2628
TH	110	370	208.6842	71.60544
SODIUM	45	134	81	22.7083
POTASSIUM	1.4	13	5.694737	3.395172
CALCIUM	20.04	60.12	39.44421	11.05896
MAGNESIUM	10.96	70.64	29.10368	17.97728
CHLORIDE	42.1	439	165.7895	105.7594
FLOURIDE	0.361	2.06	1.124526	0.53411
SULPHATE	5	131	65.89474	35.86842
DO	2.4	5.6	4.126316	0.626136
COD	0	11.2	5.894737	3.202338
BOD	0	4.4	2.642105	1.476601

The statistical data of water quality parameters in three seasons are shown in the table no's 8,9,10, which gives the method for determination of criteria of accuracy and precision.

Table 11-Comparison of ground water quality at the study areas with drinking water standards (IS&ICMR)

S.no	Parameter	Rainy season			Winter season			Summer season			IS	ICMR
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean		
1	PH	7.95	8.83	6.961111	7.56	8.39	7.954737	6.93	8.3	7.455789	6.5-8.5	7.0-8.5
2	EC	400	2700	655.5556	230	2200	1138.421	600	2600	1236.842	-	-
3	TDS	256	1728	419.5556	147.2	1408	728.5895	384	1664	791.1579	500	500
4	TURBIDITY	0	2	0.222222	0	1	0.315789	0	0	0	01	05
5	ALKALINITY	58	598	211.8889	180	564	387.8947	210	650	383.4737	200	600
6	TH	120	480	136.6667	110	360	218.1579	110	370	208.6842	200	300
7	SODIUM	32	174	27.33889	3	171	66.57895	45	134	81	-	-
8	POTASSIUM	1.8	14.5	5.122222	2.5	19.8	9.005263	1.4	13	5.694737	-	-
9	CALCIUM	12	80	26.11111	22	80	41.89474	20.04	60.12	39.44421	70	75
10	MAGNESIUM	8.53	81.61	17.39	10.96	59.68	27.62789	10.96	70.64	29.10368	35	60
11	CHLORIDE	30.4	663	16.09189	43.1	1280	326.2895	42.1	439	165.7895	250	200
12	FLOURIDE	0.137	1.91	0.2184	0.433	3	1.592895	0.361	2.06	1.124526	1.5	1.0
13	SULPHATE	5	142	34.05556	10	145	81.63158	5	131	65.89474	250	200
14	DO	3.4	7.6	5.377778	3.6	5.2	4.2	2.4	5.6	4.126316	-	-
15	COD	0	19.2	19.69444	4	70.4	26.2	0	11.2	5.894737	-	-
16	BOD	0.6	5	1.677778	0.8	3.2	1.905263	0	4.4	2.642105	-	-

Results and Discussions

The water samples collected in three seasons in the study area have no odour but they have acceptable taste with clear in appearance. The sample numbers, villages names, geology and GPS details are shown in table 1. The physico-chemical analysis are shown in tables 2,3,4. The correlation coefficient matrix of

water quality are shown in tables 5,6,7. Statistical data of various parameters are shown in table 8,9,10. Table 11 indicates the comparison of ground water quality with IS and ICMR standards.

In the rainy season the pH values of the most of the samples except 7,10,11 and 14 are within the range. The samples 7,8,9,12,13,16 and 17 contains higher amounts of TDS. The remaining samples except 4 and 5 contains TDS values beyond the desirable limit. The alkalinity values are beyond the desirable limit except in samples 1 and 4. Sample no's 2,8,9,11,15,16,17,18 and 19 contains higher concentrations of TH than the desirable limit. But the TH values in sample 12 and 13 are beyond the permissible limit. Sample no's 12,16 and 17 contains higher concentration of calcium beyond the desirable limit. The magnesium concentrations are beyond the desirable limit in samples 9,11,12,13,14 and 16. The samples 12,13,14 and 16 contains chloride concentration beyond the permissible limit. The chloride concentrations in the remaining samples are within the desirable limit. Samples 7,9 and 10 contains higher amounts of fluoride than the permissible limit. The values of other parameters like sodium, potassium, iron, nitrite, sulphates and phosphates are well within the desirable limits.

In winter season the pH values of all the samples are within the range. The samples 7,17 and 18 contains higher amounts of TDS. The remaining samples except 3 and 4 contains TDS values beyond the desirable limit. The alkalinity values are beyond the desirable limit except in sample 1 and 4. Sample no 2,8,9,11,12,13,14,15,16,17 and 18 contains higher concentrations of TH than the desirable limits. Sample no 18 contains higher concentrations of calcium beyond the desirable limit. The magnesium concentrations are beyond the desirable limit in samples 11,13,16 and 17. Sample no's 13,17 and 18 contains chloride concentrations beyond the permissible limit. The chloride concentrations in the remaining samples are well within the desirable limits. Sample 7,8,9,10,11,13,15 and 19 contains higher amount of fluoride than the permissible limit. The values of other parameters like sodium, potassium, iron, nitrite, sulphates and phosphates are well within the desirable limits.

In summer season the pH values of all the samples are within the range. The samples no 13,17 contain high amount of TDS. The remaining samples except sample no 1 contain the TDS values beyond the desirable limit. The alkalinity values of all the samples are beyond the desirable limit. The sample no 1,5,9,11,12,15,16,17,19. contain high concentration of TH value than desirable limit. Calcium values of all the samples are well with the desirable limits. The magnesium concentration is beyond the desirable limits in the sample no 11,12,13,16,17. The sample no 12,13,16. Contain chlorine concentration beyond the desirable limits. The fluoride concentration in the sample no 7,10,11,12,13,15,19 is higher than the desirable limit. The values of other parameters like sodium, potassium, iron, nitrite, sulphates and phosphates are well within the desirable limits.

Conclusion:

The Ground water is only source for people in the study area and the results of the chemical analysis of ground water indicates considerable variations. Most of the water samples comply with Indian and ICMR standards for drinking purpose. If there is no alternative source is available we can use for drinking within the permissible limits. The water quality in the investigated area is found to be suitable for drinking except few samples. All parameters values for sample no's 13,16,17 are in permissible limits in three seasons.

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