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LINEAR CORRELATION ANALYSIS AND CONTOUR MAPS- STUDY OF GROUND WATER QUALITY OF BUTTAYAGUDEM MANDAL WESTGODAVARI DISTRICT, ANDHRAPRADESH, INDIA

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ABSTRACT

Buttayagudem mandal lays in northern part of the west godavari district of AP. Ground water is the only source for drinking as well as irrigation.18 samples were collected from the Mandal and drinking water quality parameters like pH, turbiditry, TDS, TH, TA, chloride, fluoride, nitrite, sulphate, sodium, potassium, calcium ,magnesium ,iron, DO,BOD and COD were determined. The results were compared with ICMR standards of water quality. Correlation coefficients were determined, which give hydro chemical relation among different chemical parameters. Contour maps which give geographical view of the study area were also prepared .

Keywords: Ground water, water quality, correlation coefficient matrix , contour maps.

1.Introduction

water is the god's wonderful gift to the all living beings. Different types of water sources are available in the form of rainwater, rivers, seas, ground water. But 97% of water exists in the form of seas, which is unfit for hum activities. Only 3% of water is available to the humans in the form of rivers, lakes and ground water. This 3% is not enough for human activities but we don't have other choice so we should properly use and protect available water sources. In the present world for all economical activities i.e agriculture ,industries, fisheries, ground water is a major source, lack of awareness about importance of water to the people, they were polluting the water through different activities due to this reason different chemical parameters concentration were crossing the defined limits, this is not good for human health therefore suitability of water sources for human consumption has been described on the basis of WHO and ICMR guide lines. The main aim of present work is to assess the quality of ground water for human consumption on the basis of correlation coefficient data analysis.

2.Study Area

The West godavari district consists of 46 mandals out of which 24 mandals are upland areas and 22 mandals are delta areas. One upland mandal , Buttayagudem is selected for the analysis of various parameters of ground water samples seasonally . Butttayagudem is located in between 17.18358 to 17.31718 North latitude and 81.25935 to 81.45478 East longitude.

Figure 1-view of AP in india

Figure 2-view of districts in AP

Figure 3-view of Mandals in westgodavari map

Figure 4-Buttayagudem Mandal map

3 Methodology:

All physical,chemical and biological parameters of ground water sample were determined by adopting standard analytical methods which are listed below.

S.NO	PARAMETERS	STANDARD ANALYTICAL METHODS
1	PH	Eutech- 2700 pH meter
2	EC	Systronics-304 EC meter
3	TDS	Eco tester TDS low meter
4	Turbidity, sulphate	Nephaloturbidity-132
5	Alkalinity	Volumetrically byH2SO4
6	TH,Ca+2,Mg+2	Complexometrically by EDTA
7	Sodium, potassium	Flame photometer-127
8	Chloride ,fluoride	Ion slectivity meter-eutech 2700
9	Iron, phosphate, nitrite	Visible spectrophotometer
10	DO,BOD,COD	Standard methods

Table 1- Normal statistics of ground water samples in rainy season

PARAMETER	MIN	MAX	MEAN	SD	CVR
PH	6.08	7.94	6.961111	0.488694	7.020351
EC	200	1500	655.5556	385.3527	58.78262
TDS	128	960	419.5556	246.6258	58.78262
TURBIDITY	0	2	0.222222	0.548319	246.7435
ALKALINITY	70	430	211.8889	126.5719	59.73506
TH	55	280	136.6667	67.16967	49.14854
SODIUM	3.8	70	27.33889	67.16967	91.34056
POTASSIUM	2	15.5	5.122222	67.16967	69.58489
CALCIUM	6	62	26.11111	67.16967	66.01951
MAGNESIUM	4.87	45.07	17.39	67.16967	59.13791
CHLORIDE	0.597	70.33	16.09189	67.16967	113.3077
FLOURIDE	0.066	0.599	0.2184	67.16967	68.10012
SULPHATE	6	82	34.05556	67.16967	62.94988
DO	3.6	9.2	5.377778	67.16967	31.26906
COD	1.4	25.6	19.69444	67.16967	26.34385
BOD	0.8	3.2	1.677778	67.16967	40.71066

Table 2- Normal statistics of ground water samples in winter season

PARAMETER	MIN	MAX	MEAN	SD	CVW
PH	6.83	7.9	7.274444	0.35472	4.876246
EC	200	1300	638.8889	308.962	48.35927
TDS	128	832	408.8889	197.7357	48.35927
TURBIDITY	0	20	1.277778	4.687977	366.8851
ALKALINITY	122	464	238.6667	115.2511	48.28958
TH	60	270	146.9444	62.61786	42.61329
SODIUM	1	84	35.5	29.97499	84.43659
POTASSIUM	2	12	5.788889	3.21099	55.46816
CALCIUM	14	70	32.88889	15.49531	47.11411
MAGNESIUM	0	49.94	15.76667	11.02561	69.92987
CHLORIDE	1.63	244	58.70389	64.74616	110.2928
FLOURIDE	0.147	1.15	0.457444	0.321617	70.3074
SULPHATE	4	82	29.5	21.0245	71.26948
DO	3.6	4.8	4.288889	0.330577	7.70775
COD	0	84.8	13.77778	19.03568	138.1622
BOD	1.2	3.6	2.377778	0.589671	24.79927

Table 3- Normal statistics of ground water sample in summer season

PARAMETER	MIN	MAX	MEAN	SD	CVS
PH	6.67	8.09	7.236111	0.393956	5.444311
EC	200	1400	611.1111	351.2815	57.48243
TDS	128	896	391.1111	224.8202	57.48243
ALKALINITY	62	410	187.5556	111.1344	59.25411
TH	55	435	151.1111	94.39522	62.46742
SODIUM	11	94	46.22222	26.78796	57.95472
POTASSIUM	0.2	8	3.311111	2.335629	70.53913
CALCIUM	14.03	84.17	36.40556	22.24395	61.10043
MAGNESIUM	4.87	54.81	14.68278	11.49057	78.25884
CHLORIDE	4.02	174	37.45222	45.5488	121.6184
FLOURIDE	0.206	1.34	0.553128	0.319498	57.76204
SULPHATE	9	80	28.05556	18.20301	64.88203
DO	2.8	5.6	3.977778	0.75736	19.03979
COD	0	57.6	19.28889	25.69671	133.2203
BOD	1.2	3.2	2.044444	0.492559	24.09256

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 graterthan 0 indicates positive linear association, r value is lessthan 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 4- 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	0.448514	1													
TDS	0.448514	1	1												
Alkalinity	0.447367	0.916952	0.916952	1											
Hardness	0.449018	0.983649	0.983649	0.873748	1										
Sodium	0.488875	0.929536	0.929536	0.922346	0.87702	1									
Potassium	0.06935	0.234169	0.234169	0.077665	0.242465	0.235368	1								
Calcium	0.495887	0.811917	0.811917	0.890756	0.792341	0.747136	-0.06495	1							
Magnesium	0.20819	0.73637	0.73637	0.481011	0.782374	0.63281	0.452135	0.239944	1						
Chloride	0.406072	0.915851	0.915851	0.73902	0.921718	0.78579	0.183792	0.641114	0.812205	1					
Fluoride	0.323558	0.679397	0.679397	0.811082	0.683158	0.645772	-0.08546	0.904777	0.163449	0.460539	1				
Sulphate	0.418012	0.779298	0.779298	0.558182	0.782623	0.694138	0.559418	0.438028	0.798192	0.81125	0.304054	1			
DO	0.234817	0.107318	0.107318	-0.13831	0.144084	0.131393	0.503758	-0.12735	0.359251	0.116068	-0.2237	0.333237	1		
COD	0.0197	0.065186	0.065186	0.045217	0.05784	0.184619	0.24917	-0.1485	0.243628	0.053231	-0.04189	0.159086	0.320246	1	
BOD	-0.25792	-0.04867	-0.04867	-0.27995	-0.0453	-0.06371	0.471859	-0.39045	0.326577	0.041035	-0.31595	0.285714	0.515785	0.179732	1

Table 5- 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	0.740099	1													
TDS	0.740099	1	1												
Alkalinity	0.84189	0.864859	0.864859	1											
Hardness	0.684439	0.938423	0.938423	0.837645	1										
Sodium	0.457024	0.501463	0.501463	0.462531	0.403889	1									
Potassium	0.235959	0.285663	0.285663	0.118377	0.053506	0.45959	1								
Calcium	0.499451	0.709915	0.709915	0.517312	0.695303	0.207953	0.244228	1							
Magnesium	0.519385	0.690642	0.690642	0.71607	0.788376	0.380808	-0.13507	0.10601	1						
Chloride	0.430749	0.814728	0.814728	0.563228	0.806705	0.320291	0.040731	0.576423	0.622689	1					
Fluoride	0.598875	0.423081	0.423081	0.652652	0.524749	0.328694	-0.37256	0.112852	0.629425	0.205804	1				
Sulphate	0.541872	0.83448	0.83448	0.541553	0.690664	0.324029	0.565934	0.696968	0.358928	0.717552	-0.02372	1			
DO	-0.00959	0.113907	0.113907	-0.11281	0.209971	0.015435	-0.38471	0.057163	0.24159	0.367986	0.158728	0.096485	1		
COD	0.097585	0.044363	0.044363	-0.13957	0.128594	0.018392	0.08965	0.099625	0.092636	0.101494	-0.22827	0.188251	0.329376	1	
BOD	0.056745	0.560369	0.560369	0.342991	0.584313	0.143104	0.039628	0.301005	0.55074	0.689356	-0.07389	0.511486	0.324565	0.109375	1

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

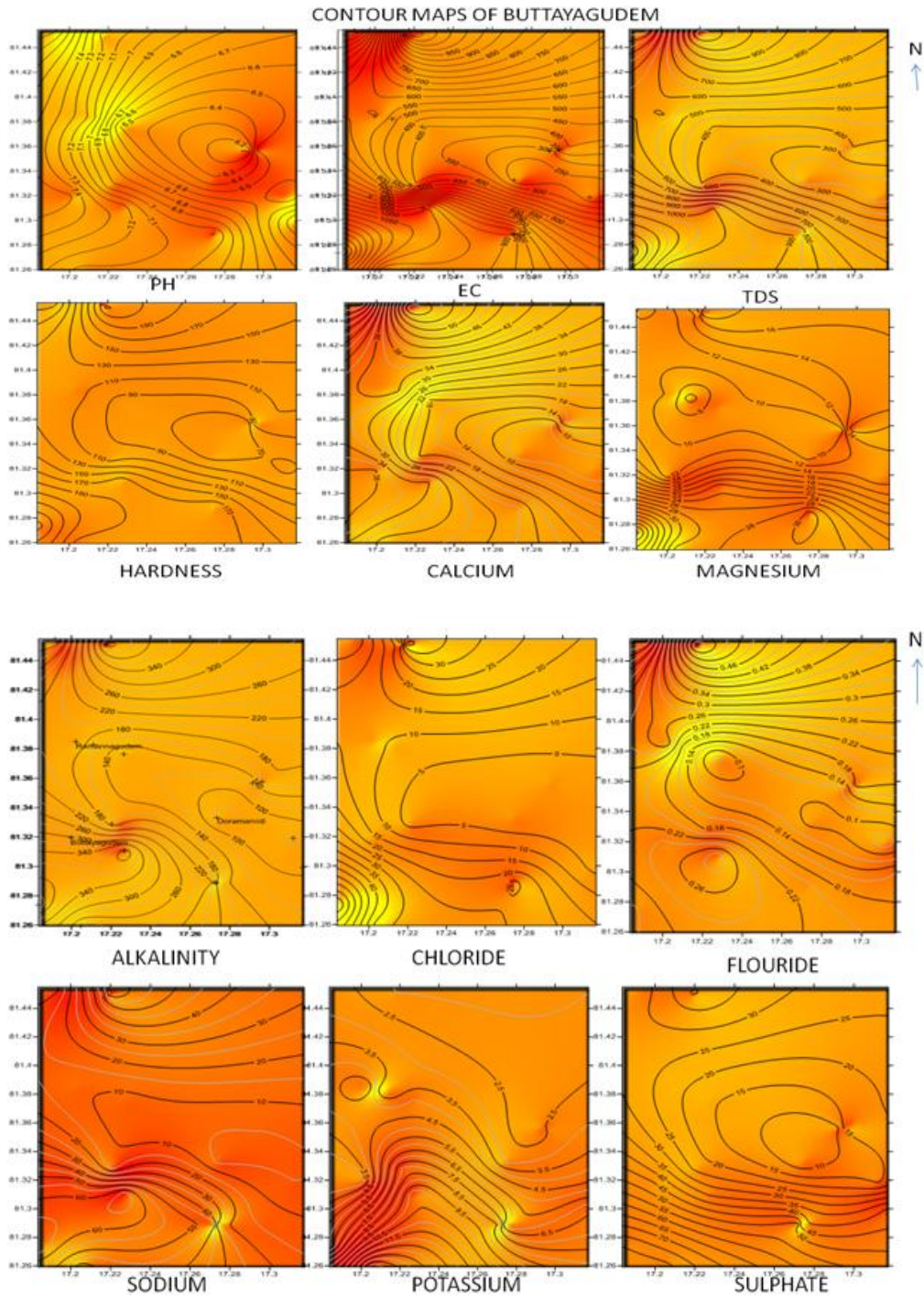|	pH	E.C	TDS	Alkalinity	Hardness	Sodium	Potassium	Calcium	Magnesium	Chloride	Fluoride	Sulphate	DO	COD	BOD
pH	1														
E.C	0.040711	1													
TDS	0.040711	1	1												
Alkalinity	0.207886	0.926798	0.926798	1											
Hardness	0.143039	0.892799	0.892799	0.896655	1										
Sodium	0.049639	0.891128	0.891128	0.817145	0.71104	1									
Potassium	-0.23451	0.175495	0.175495	-0.02903	-0.03568	0.480386	1								
Calcium	0.152093	0.939352	0.939352	0.953861	0.932047	0.780474	-0.03712	1							
Magnesium	0.107473	0.681419	0.681419	0.672111	0.904581	0.50456	-0.02785	0.688648	1						
Chloride	0.168918	0.930097	0.930097	0.854669	0.825654	0.770101	0.149275	0.871659	0.626736	1					
Fluoride	0.102181	0.689567	0.689567	0.794337	0.746304	0.539586	-0.27726	0.798142	0.554491	0.521521	1				
Sulphate	0.063439	0.824151	0.824151	0.68549	0.64048	0.821367	0.406342	0.67914	0.482623	0.805709	0.381258	1			
DO	0.095115	-0.68001	-0.68001	-0.61402	-0.54762	-0.50656	0.17839	-0.61809	-0.36865	-0.60406	-0.57463	-0.34808	1		
COD	0.038433	0.062443	0.062443	-0.17222	-0.07066	0.024307	0.36505	-0.08616	-0.04002	0.200413	-0.29028	0.416695	0.180009	1	
BOD	0.438679	-0.52657	-0.52657	-0.39249	-0.37308	-0.56341	-0.30009	-0.34782	-0.3372	-0.42997	-0.1723	-0.49234	0.620928	0.042798	1

The results in table 4 indicate that Ca^{+2} and Mg^{+2} are correlated with TH (r=0.792 and r=0.782 respectively). Cl^- and SO_4^{2-} are correlated with Mg (r=0.812 and r=0.798 respectively) which indicates the dissolved salts. TH is strongly correlated with TDS (r=0.90) indicating that hardness causing salts impart more towards TDS.

The correlation coefficient matrix in table 5 indicate that Ca and Mg are correlated with TH (r=0.695 and r=0.788 respectively). Cl^- and SO_4^{2-} are correlated with TH (r=0.806 and r=0.690 respectively). Cl^- and SO_4^{2-} are also correlated with Ca and Mg.
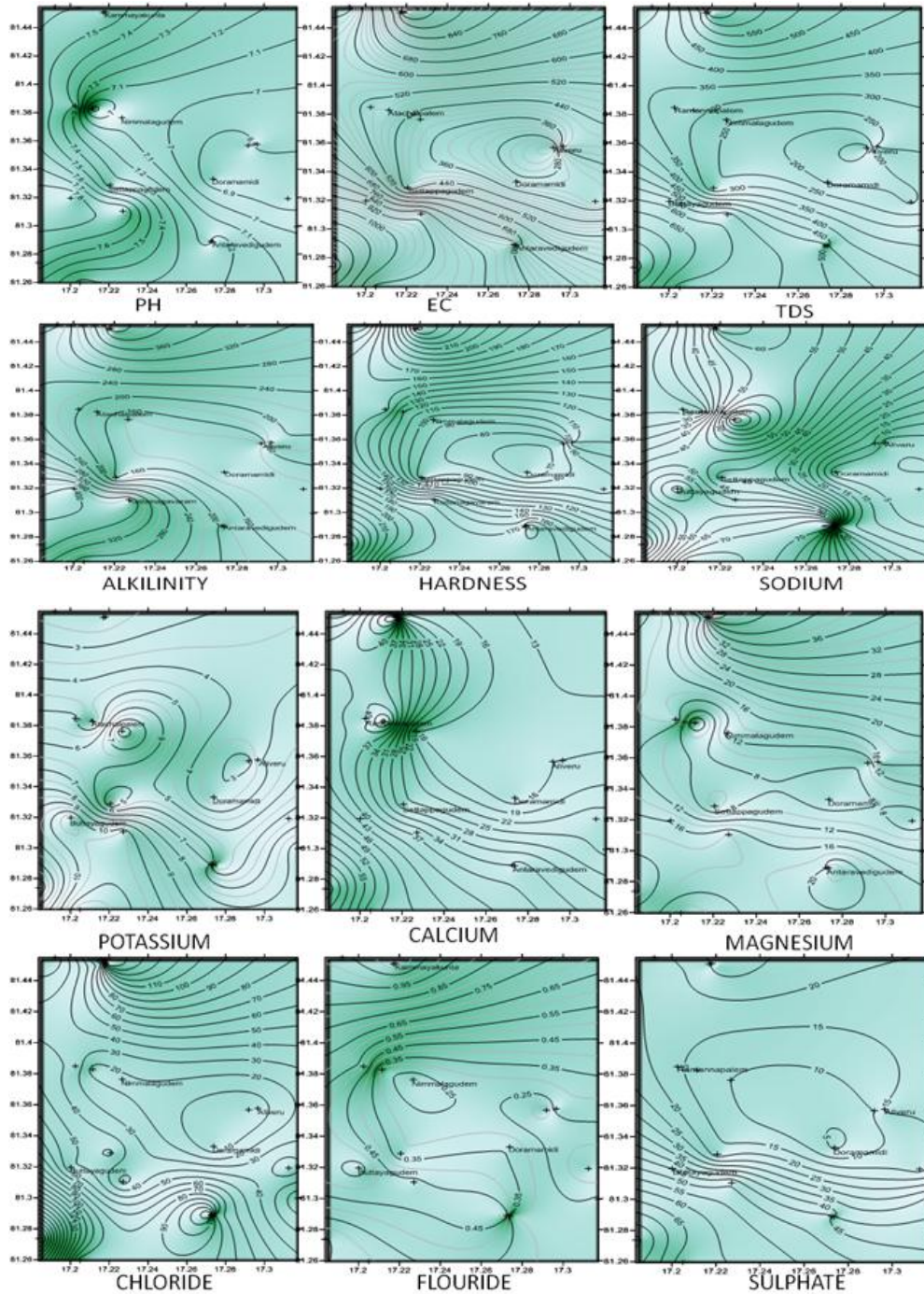
The results in table 6 show that Ca and Mg are strongly correlated with TH (r>0.9), TH correlated with TDS (r=0.892), Cl is correlated with TH , Ca and Mg and SO4 is correlated with TH and Ca.

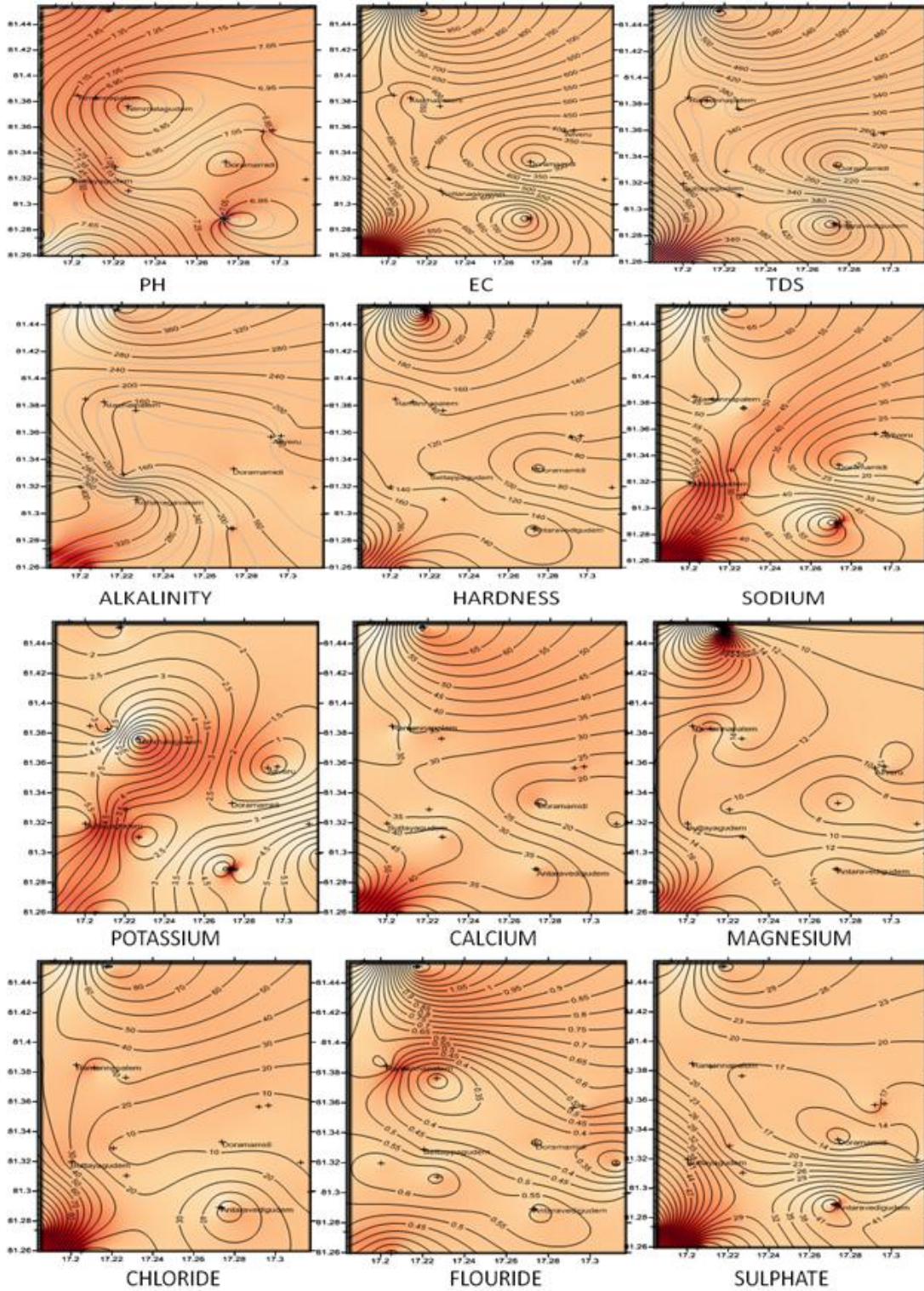| Contour Maps of Parameters - Buttayagudem Mandal |
|---|

Rainy Season

CONTOUR MAPS OF BUTTAYAGUDEM

Winter Season

Summer Season

PH

EC

TDS

ALKALINITY

HARDNESS

SODIUM

POTASSIUM

CALCIUM

MAGNESIUM

CHLORIDE

FLOURIDE

SULPHATE

The spatial distribution of pH increased from Northeast and Southeast parts of study area to the west .The spatial distribution of EC, TDS, TH, Alkalinity, Ca^{+2} ,Cl^-, Na^+ were similar with lower values in central part of study area and increases in Northwest and Southwest directions. Mg^{+2} which is having low value at Atachaipalem and increases in south direction. The concentration of K^+ is high at South and decreases towards North.SO_4^{2-} concentration is high at Southwest and decreases towards centre. Flouride concentration had a different distribution, being low value in the centre and its value increases in North direction.

The spatial distribution of pH is similar as in rainy season. The spatial distribution of EC, TDS, TH, Alkalinity were similar with lower values in central part of study area and increases in North, West ,East directions and are mostly concentrated at South west . Na^+ concentrations were low at Doramamidi and its value increases towards North but at Ramannapalem the concentraion of sodium is high. The distribution of SO_4^{2-} increased from Northwest towards Ramannapalem and then decreases .The spatial distribution of Flouride is similar as in rainy season .Concentrations of K^+ increases from northwest towards south west. Concentrations of Ca^{+2} are increased from northeast towards south west . In the central part of study area the concentration of Mg^{+2} is low and it increases towards north east. The concentration of Cl^- is less in centre part and it increases towards north and south west directions.

The spatial distribution of pH in summer season has slight variation when compare to rainy and winter seasons .It has minimum value at Nimmalagudem and the concentration increases towards southwest direction .The distribution of EC, TDS, TH, Ca^{+2} were similar which are having lower values at Doramamidi and increases towards north, south directions. The values of alkalinity decrease as we move towards the centre part of study area .Na^+ concentration had different distribution, highest value at Buttayagudem and then decreases towards Ramannapalem and then again increases towards north. The Cl^- ion concentrtion is low in the vicinity of Doramamidi and increases towards north and southwest directions. The concentration of SO_4^{2-} is relatively high towards southwest and low in other parts of study area

Conclusions

The quality of ground water samples collected from Buttayagudem mandal in three seasons were analysed and studied . Based on these analytical studies we may conclude that the values of all parameters in three seasons are in permissible limits. On the basis of correlation we may conclude that there is a strong relation between total hardness and TDS . The hardness producing ions Ca^{+2} and Mg^{+2} are strongly correlate with chloride and sulphate which indicates it has permanent hardness .Contour maps are also included in this research paper which gives the spatial distribution of various parameters in three seasons in study area.

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