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Research Article

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Evaluation of ground water quality in rural habitations near agricultural activity by physicochemical characterization to assess their potentials for application

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ABSTRACT

Water is a significant natural resource which is vital for the survival of all ecosystems on the planet of the earth. Agricultural activities with their intensive utilization of agro chemicals pose a significant potential for negative impact on the quality of ground water. Expansion and intensification of cultivation are among the predominant global changes of this century. Use of chemical fertilizers and pesticides has contributed to the tremendous increase in food production over the past 50 years. The purpose of the present study is to provide a better understanding of the impact of agricultural activities on ground water quality in rural habitations near agricultural activity in East Godavari District, Andhra Pradesh, India. Impacts have been assessed through the systematic collection of ground water samples in the study areas and characterized for a range of physicochemical parameters viz., pH, EC, TDS, TH, Ca^{2+},Mg^{2+},TA,Na, K, Cl^{-}, SO_4^{2-}, PO_4^{3-},F^{-}, NO_3^{-} and also for determining the irrigation parameters to evaluate the quality of ground waters for assessing their potentials for application. The research results revealed that waters are slightly alkaline. Higher values of EC in case of certain water samples indicate their saline nature. Higher TDS levels indicate the presence of soluble solids in waters. Higher values of TH indicate the encrustation of waters on water supply systems and make the waters unsuitable for domestic purposes.

Key words: Ground water, Agriculture, Characterization, Parameter, Application

INTRODUCTION

Population growth and increase in living standards and the demand for food production are the driving forces for expansion and intensification of agriculture. Out of the world's total land 13 billion hectares 12 percent is cultivated [1].In the developing countries, this intensification under the general heading 'the green revolution" which started in the year 1960 with the transfer and dissemination of high yielding seeds [2]. The dramatic change of agricultural practices during the last 50 years is also a factor for environmental degradation especially through its impacts on soil and water resources. In the last decades there is an enhancing interest in crop production system which optimize yields while conserving soil, water, energy and protecting the environment [3].

Water is a significant natural resource which is vital for the survival of all ecosystems on the planet. However, less than 1 percent of earth's water resources are accessible to humans as fresh water in the form of either surface or ground water [4][5]. Problems associated with water quality are commonly attributed to nutrient, chemical and pathogenic loadings in to water resources as a result of point source and non-point source activities [6].

Surface and ground water contamination is mainly attributed to outdated management practices which include excessive use of fertilizers for high product yields, traditional irrigation practices, use of pesticides and poorly managed animal farming operations [7][5]. Fertilizers rich in phosphorus and nitrogen are added to soil to enhance

crop yields. However, agronomic nutrient recommendations are often for in excess of environmental levels [8]. Application of nutrients through manures and artificial fertilizers often remain in the soil or leached in to the drainage water. Keeping in view the hectic agricultural activity in East Godavari District of Andhra Pradesh, India, it is proposed to collect ground waters from the nearby agricultural activity areas and to characterize them for physicochemical parameters to evaluate the quality of waters and to assess their potentials for application [9][10].

EXPERIMENTAL SECTION

The sampling locations are identified in the nearby agricultural activity areas selected for the present research study are located in East Godavari region of Andhra Pradesh and the details are presented in Table-1

Table-1: Sample code and Sampling locations

Sample Code	Mandal HQ	Sample Location	Location Coordinates	
			Longitude	Latitude
Amalapuram Division				
A-1	Amalapuram(Rural)	Bhatnavilli	$N16^{0}35.5333^{1}$	$E82^{0}01.992^{1}$
A-2	Amalapuram(Urban)	Savaram	$N16^{0}35.369^{1}$	$E82^{0}00.177^{1}$
A-3	Allavaram	Allavaram	$N16^{0}31.988^{1}$	$E81^{0}59.582^{1}$
A-4	Mamidikuduru	Pasarlapudi badava	$N16^{0}31.316^{1}$	$E81^{0}56.863^{1}$
A-5	Razole	Sivakodu	$N16^{0}27.726^{1}$	$E81^{0}50.191^{1}$
A-6	Malikipuram	Lakkavaram	$N16^{0}25.757^{1}$	$E81^{0}50.655^{1}$
A-7	P.Gannavaram	Mondepulanka	$N16^{0}33.711^{1}$	$E81^{0}53.020^{1}$
A-8	Ambajipeta	Machavaram	$N16^{0}36.019^{1}$	$E81^{0}55.528^{1}$
A-9	Inavilli	Vilasa	$N16^{0}37.773^{1}$	$E82^{0}01.423^{1}$
A-10	Mumidivaram	Krapachintalapudi	$N16^{0}38.326^{1}$	$E82^{0}04.949^{1}$
A-11	Katrenakona	Inapuram	$N16^{0}36.561^{1}$	$E82^{0}08.668^{1}$
A-12	I.Polavaram	Komaragini	$N16^{0}42.114^{1}$	$E82^{0}11.565^{1}$
Ramachandrapuram Division				
R-1	Ragampeta	Pedarayavaram	$N17^{0}05.556^{1}$	$E82^{0}08.421^{1}$
R-2	Ramachandrapuram	Chodavaram	$N16^{0}51.058^{1}$	$E82^{0}03.130^{1}$
R-3	Rayavaram	Pasalapudi	$N16^{0}50.863^{1}$	$E82^{0}01.049^{1}$
R-4	Mandapeta	Arthamuru	$N16^{0}52.645^{1}$	$E81^{0}56.723^{1}$
R-5	Anaparty	Ramkota	$N16^{0}51.559^{1}$	$E81^{0}58.323^{1}$
R-6	Gangavaram	Kunduru	$N16^{0}45.325^{1}$	$E82^{0}04.778^{1}$
R-7	Kajuluru Mandal	Kolanka	$N16^{0}44.487^{1}$	$E82^{0}09.778^{1}$
R-8	Tallarevu	Sunkatarevu	$N17^{0}05.060^{1}$	$E82^{0}03.204^{1}$

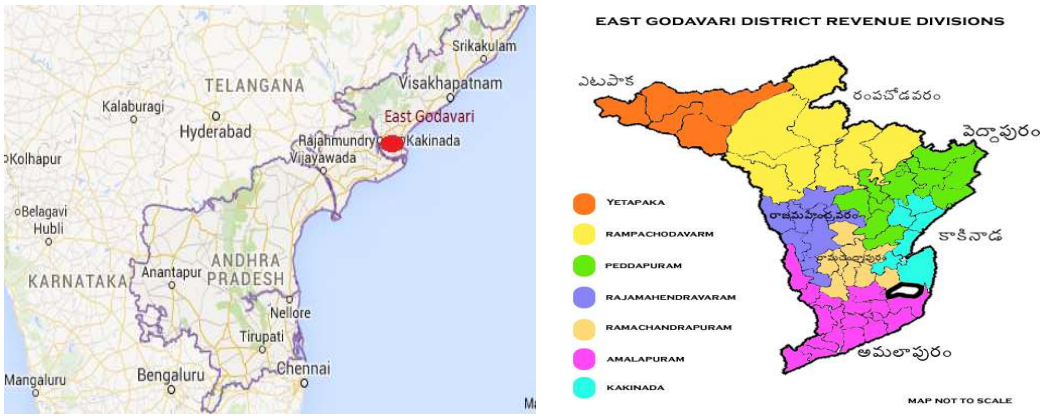


Fig-1: Study area Map

Polythene containers were employed for sampling and preserved for analysis by following the standard procedures [11]. The samples were analyzed for physicochemical parameters which include pH , Electrical conductivity (EC) , Total Dissolved solids (TDS), Total Alkalinity (TA), Total hardness (TH), Ca^{2+} and Mg^{2+}, Na^{+}, K^{+}, Chloride, Sulphate and Phosphate. pH determined by pH meter (Global-DPH 505, India-Model) and Conductivity measured by the digital Conductivity meter (Global-DCM-900-Model). TDS is determined from the relation TDS = Electrical conductivity (EC) ×0.64. Chloride, TH, TA and Chloride are estimated by titrimetry. Fluoride, Sulphate, Nitrate and Phosphate by Spectrophotometer (Model-167, Systronics), Na^{+} and K^{+} by Flame Photometer (Model-125, Systronics). The irrigation parameters determined for these waters include Percent Sodium (%Na), Sodium

Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Kelly's Ratio (KR), Magnesium Hazard (MH) and the parameters are determined by the following relation

$$\text{Percent Sodium (\%Na)} = \frac{Na^{+}X100}{Ca^{2+}+Mg^{2+}+Na^{+}+K^{+}} \text{ (meq/l)}$$

$$\text{Sodium Adsorption Ratio (SAR)} = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}} \text{ (meq/l)}$$

$$\text{Residual Sodium Carbonate (RSC)} = (CO_3^{2-} HCO_3^{-}) - (Ca^{2+}+ Mg^{2+}) \text{ (meq/l)}$$

$$\text{Kelly's Ratio (KR)} = \frac{Na^{+}}{Ca^{2+}+Mg^{2+}}$$

$$\text{Magnesium Hazard (MH)} = \frac{Mg^{2+}}{Ca^{2+}+Mg^{2+}} X100$$

RESULTS AND DISCUSSION

The analytical data related to Physicochemical and irrigation parameters are presented tables-2, 3 & 4 respectively.

Table-2: Physicochemical characteristics of ground waters

Sample Code	pH		EC µmhos/cm		TDS mg/l		TA		TH		Ca^{2+} (mg/l)		Mg^{2+} (mg/l)	
	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon
Amalapuram Division														
A-1	8.8	7.4	510	749	326.4	479.36	70	140	100	560	12	24	17.08	122
A-2	9	7.8	1380	1440	883.2	921.6	110	140	160	460	32	32	19.52	92.72
A-3	8.9	7.7	2970	2530	1900.8	1619.2	150	240	230	540	48	16	26.84	122
A-4	9.1	7.5	1220	1600	780.8	1024	110	220	230	580	8	16	51.24	131.76
A-5	8.9	7.4	430	636	275.2	407.04	80	140	100	420	8	24	19.52	87.84
A-6	8.8	7.8	392	647	250.88	414.08	90	120	80	380	16	24	9.76	78.08
A-7	8.7	7.6	271	530	173.44	339.2	50	140	80	340	12	24	12.2	68.32
A-8	8.7	7.4	491	1030	314.24	659.2	60	160	100	660	16	32	14.64	141.52
A-9	8.7	7.6	593	891	379.52	570.24	50	140	130	420	16	72	21.96	58.56
A-10	8.9	7.7	916	436	586.24	279.04	100	120	120	360	8	24	24.4	73.2
A-11	8.6	7.8	763	1470	488.32	940.8	50	140	200	620	24	64	34.16	112.24
A-12	8.8	8.2	234	242	149.76	154.88	40	60	50	160	8	16	7.32	29.28
Ramachandrapuram Division														
R-1	8.7	8.5	1880	1810	1203.2	1158.4	110	340	330	700	4	32	78.08	151.28
R-2	9	8	428	462	273.92	295.68	80	240	70	240	20	24	4.88	43.92
R-3	8.8	8.3	393	426	251.52	272.64	50	280	100	340	12	16	17.08	73.2
R-4	8.9	8	403	505	257.92	323.2	60	380	80	440	8	16	14.64	97.6
R-5	8.8	7.6	235	340	150.4	217.6	40	340	60	320	16	32	4.88	58.56
R-6	8.6	7.6	553	785	353.92	502.4	50	340	90	520	12	24	14.64	112.24
R-7	8.8	7.6	2020	1180	1292.8	755.2	140	420	150	220	12	24	29.28	39.04
R-8	9	7.5	658	905	421.12	579.2	80	300	200	480	44	56	21.96	82.96

Table-3: Physicochemical characteristics of ground waters

Sample Code	Na (mg/l)		K (mg/l)		CO_3^{-2} (mg/l)		HCO_3^- (m g/l)		Chloride (mg/l)		Sulphate (mg/l)		Nitrate (mg/l)		Phosphate (mg/l)	
	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon
Amalapuram Division																
A-1	62.8	48.48	4.52	3.3	6	12	73.2	146.4	74.445	92.17	BDL	24	1.37	ND	BDL	11.3
A-2	238.9	119.7	20.5	17.05	18	12	97.6	146.4	134.71	163.07	BDL	38	6.48	6.0	18.9	19.2
A-3	730.4	579.1	33.5	17.7	18	24	146.4	244.0	280.055	319.05	201	130	23.77	8.0	10.3	15.9
A-4	109.4	89.59	17.19	16.34	24	12	85.4	244.0	205.61	212.7	BDL	03	12.69	22.0	8.5	7.7
A-5	3.91	34.04	8.21	3.65	12	12	73.2	146.4	42.54	21.27	BDL	11	2.32	ND	2.6	5.1
A-6	37.95	33.29	5.69	5.69	6	12	97.6	122.0	35.45	42.54	BDL	15	1.63	ND	8.6	2.4
A-7	21.86	19.25	1.53	1.33	6	12	48.8	146.4	24.815	28.36	BDL	12	0.92	ND	BDL	1.4
A-8	52.68	55.37	1.05	0.9	6	12	61	170.8	42.54	77.99	BDL	29	2.28	10.0	BDL	1.8
A-9	61.5	41.53	8.07	7.38	6	12	48.8	146.4	74.445	70.9	BDL	24	1.81	1.0	2.6	9.8
A-10	206.1	19.37	10.8	2.23	6	12	109.8	122.0	99.26	28.36	BDL	10	3.08	ND	BDL	2.3
A-11	46.64	39.59	9.85	10.91	BDL	12	61	146.4	120.53	276.51	BDL	21	1.93	1.0	1.8	2.1
A-12	14.81	11.83	1.94	1.74	BDL	BDL	48.8	73.2	21.27	28.36	BDL	06	0.833	ND	0.6	1.3
Ramachandrapuram Division																
R-1	283.2	117.64	7.1	4.41	6	24	122	366.0	304.87	255.24	54	88	9.42	6.0	8.2	9.5
R-2	51.34	52.95	2.07	2.66	6	BDL	85.4	292.8	7.09	56.72	BDL	07	1.69	ND	7	6.7
R-3	36.15	34.12	0.81	1.29	BDL	36	61	268.4	17.725	92.17	BDL	**17**	1.2	**ND**	3.2	**5.4**
R-4	37.82	43.94	0.69	1.06	6	24	61	414.8	17.725	21.27	BDL	19	1.19	ND	0.8	8.1
R-5	17.29	18.87	0.26	0.84	BDL	BDL	48.8	414.8	7.09	56.72	BDL	38	0.78	ND	1	5.6
R-6	55.12	51.4	1.97	5.09	BDL	24	61	366.0	63.81	70.9	BDL	27	1.28	ND	1.4	6.4
R-7	259.6	249	89.7	18.8	12	12	146.4	488.0	272.965	120.53	109	37	6.71	1.0	4.5	10.6
R-8	37.78	45.09	26.51	57.76	6	BDL	85.4	366.0	46.085	70.9	BDL	40	5.53	18.0	9.1	19.9

Table-4: Irrigation Parametric values of ground waters

S Code	%Na		SAR		RSC		Kelly's Ratio		MH	
	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon
Amalapuram Division										
A-1	56.74	16	2.75	0.9	BDL	BDL	1.39	0.19	69.5	89.1
A-2	73.81	35.5	8.26	2.45	BDL	BDL	3.29	0.58	49.4	82.3
A-3	85.46	69.6	21.1	11	BDL	BDL	6.98	2.38	47.2	92.4
A-4	49.06	24.9	3.17	1.64	BDL	BDL	1.06	0.34	91.1	92.9
A-5	7.26	15.1	0.17	0.73	BDL	BDL	0.09	0.18	79.6	85.4
A-6	48.87	16	1.86	0.75	0.12	BDL	1.04	0.19	49.4	83.9
A-7	37.05	11.1	1.07	0.46	BDL	BDL	0.6	0.13	61.9	82.0
A-8	53.41	15.7	2.31	0.95	BDL	BDL	1.16	0.19	59.4	87.6
A-9	49.18	17.6	2.36	0.89	BDL	BDL	1.05	0.22	68.7	56.5
A-10	77.32	10.6	8.26	0.45	BDL	BDL	3.81	0.12	83	83.0
A-11	32.64	12.1	1.45	0.7	BDL	BDL	0.52	0.14	69.5	73.7
A-12	38.35	13.9	0.92	0.41	BDL	BDL	0.65	0.16	59.4	74.5
Ramachandrapuram Division										
R-1	65.01	27	6.86	1.95	BDL	BDL	1.91	0.37	96.9	88.3
R-2	60.73	32.5	2.68	1.5	0.11	0.09	1.61	0.49	28.1	74.5
R-3	44.16	**18.2**	1.59	**0.81**	BDL	**BDL**	0.8	**0.22**	69.5	**88.0**
R-4	50.86	18.1	1.86	0.92	BDL	BDL	1.05	0.22	74.5	90.7
R-5	38.57	11.5	0.97	0.46	BDL	0.52	0.63	0.13	32.8	74.5
R-6	56.82	17.8	2.55	0.99	BDL	BDL	1.35	0.22	66.1	88.2
R-7	68.31	69.3	9.31	7.36	BDL	3.88	3.84	2.5	79.6	72.2
R-8	26.17	15.2	1.17	0.9	BDL	BDL	0.42	0.21	44.4	70.3

Fig: 2-16-Graphical representation of Physicochemical & irrigation parametric values of ground water of Amalapuram Division

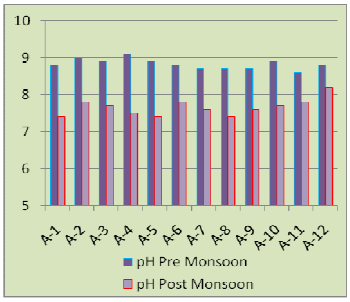


Fig-2: pH

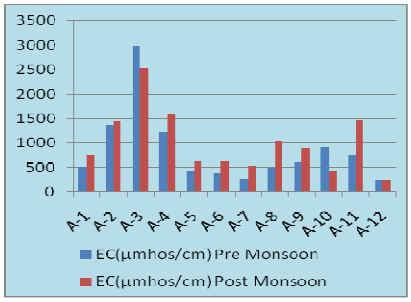


Fig-3:EC

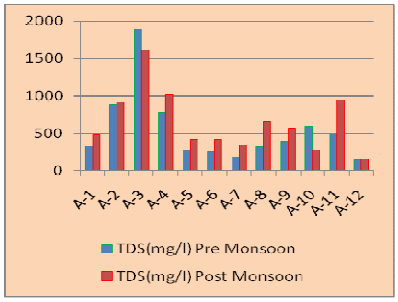


Fig-4:TDS

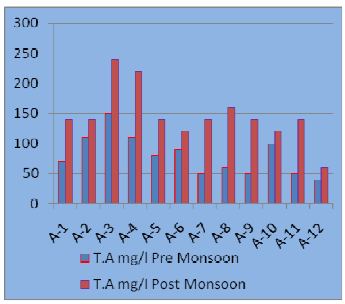


Fig-5:Total Alkalinity

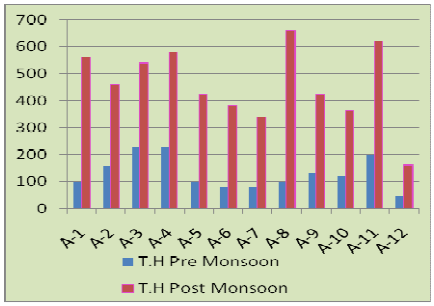


Fig-6:Total Hardness

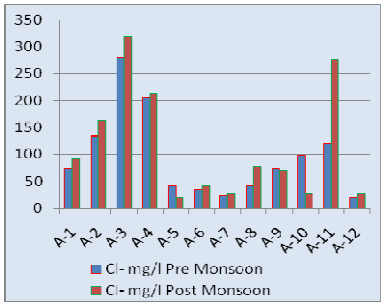
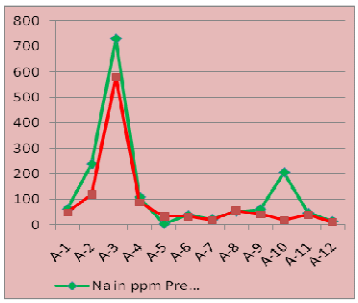
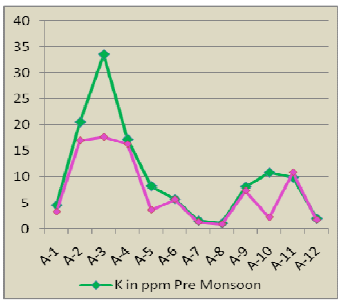


Fig-7: Chloride





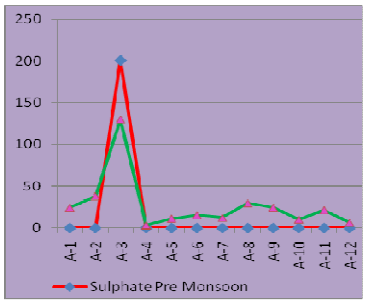
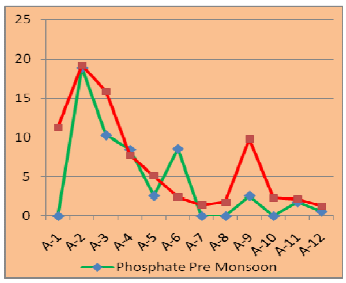
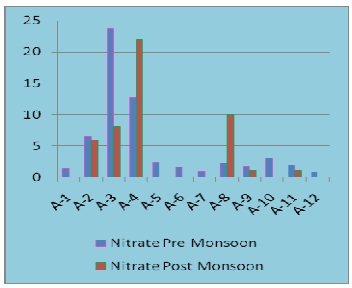


Fig-8: Sodium Fig-9: Potassium Fig-10:Sulphate





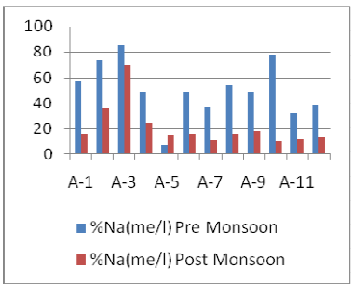
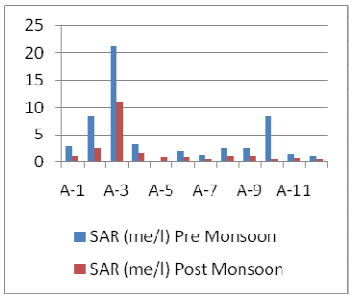
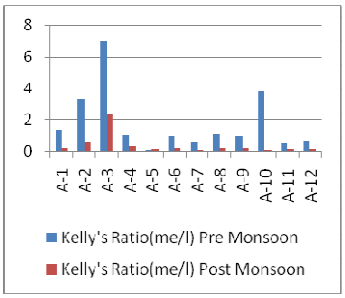


Fig-11: Phosphate Fig-12: Nitrate Fig-13:Percent Sodium





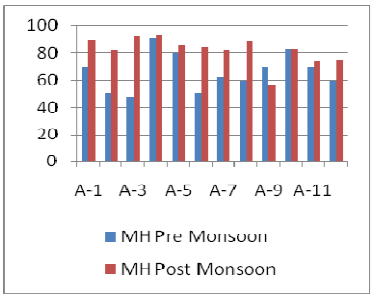
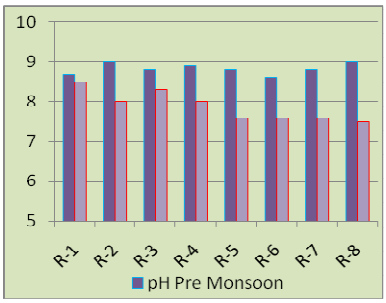
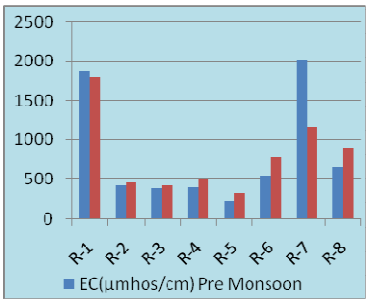


Fig-14: SAR Fig-15: Kelly's Ratio Fig-16: MH

Fig-17-31: Graphical representation of Physicochemical & irrigation parametric values of ground water of Ramachandrapuram division





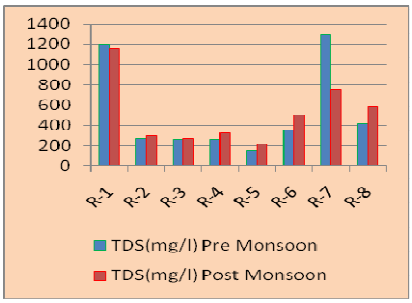
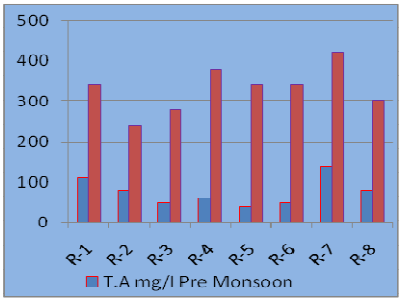
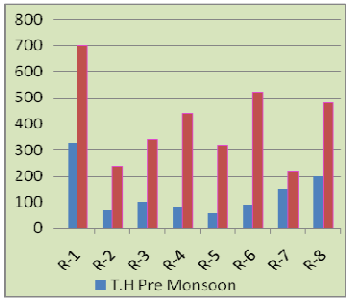


Fig-17: pH Fig-18:EC Fig-19:TDS





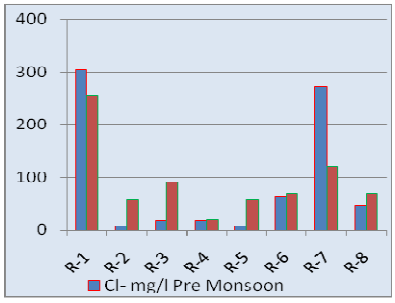
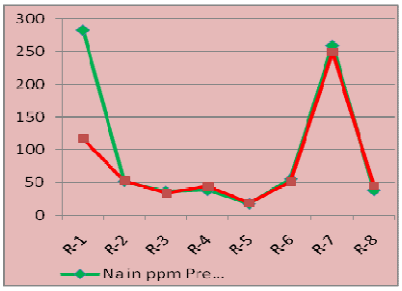
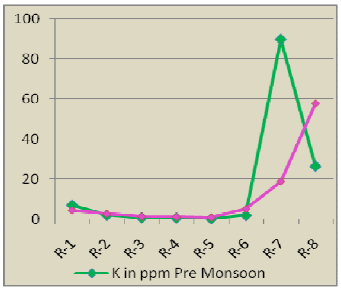


Fig-20:Total Alkalinity Fig-21:Total Hardness Fig-22: Chloride





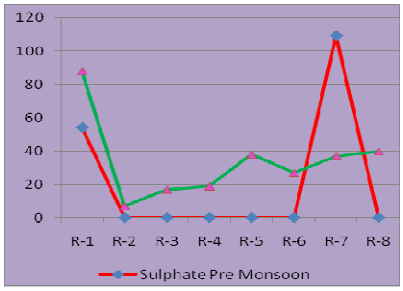
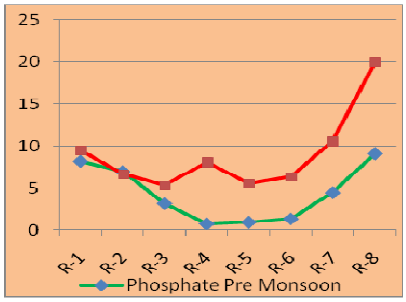
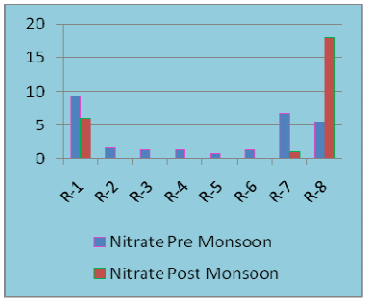


Fig-23: Sodium Fig-24:Potassium Fig-25:Sulphate





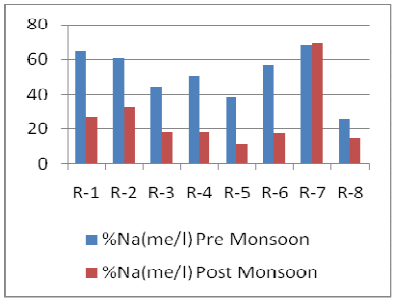
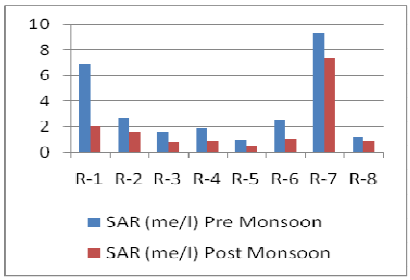
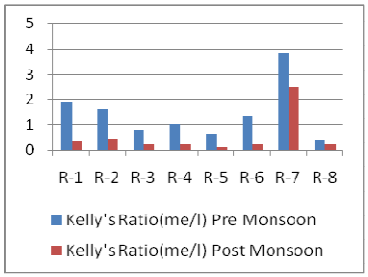


Fig-26: Phosphate Fig-27: Nitrate Fig-28: Percent Sodium





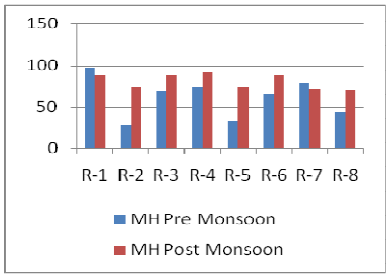


Fig-29: SAR Fig-30: Kelly's Ratio Fig-31: MH

pH: pH of waters during pre monsoon range from 8.6 - 9.1 of Amalapuram revenue division, 8.6-9.0 in Ramachandrapuram division. The pH levels indicate slight alkaline nature of ground waters. During post monsoon season pH of waters range from 7.4-8.2 in Amalapuram revenue division, 7.5-8.5 in Ramachandrapuram division indicating slight alkaline nature of ground waters.

Electrical conductivity (EC): EC of ground waters during pre monsoon season range from 234-2970 µmhos/cm in Amalapuram revenue division, from 235-2020 µmhos/cm in Ramachandrapuram division. During post monsoon season ranges from 242-2530 µmhos/cm in Amalapuram revenue division, 340-1810 µmhos/cm in Ramachandrapuram division. Waters with EC more than 4000 µmhos/cm are highly saline and are even not for consideration for irrigation purposes.

Total Dissolved Solids (TDS): TDS levels within the permissible limit (500 mg/l) can be considered for drinking purposes. **(Ref-2).** TDS of ground waters during pre monsoon season range from 149.76-1900.8 mg/l in Amalapuram revenue division, 150.4-1292.8 mg/l in Ramachandrapuram division. During post monsoon season TDS ranges from 154.88-1900.8 mg/l in Amalapuram revenue division, 217.6-1158.4 mg/l in Ramachandrapuram division. Waters with TDS more than 500mg/l indicate the presence of dissolved solids which can change the taste of the waters.

Total Alkalinity (TA): TA of ground waters during pre monsoon season range from 40-150 mg/l in Amalapuram revenue division, 40-140 mg/l in Ramachandrapuram division. During post monsoon season TA ranges from 60-240 mg/l in Amalapuram revenue division, 240-420 mg/l in Ramachandrapuram division. Waters with TA level more than 200mg/l can cause change the taste of waters and make the waters unsuitable for drinking purposes.

Total Hardness (TH): Total hardness of ground waters during pre monsoon season ranges from 50-230 mg/l in Amalapuram revenue division, 70-330 mg/l in Ramachandrapuram division. During post monsoon season TH ranges from 160-660 mg/l in Amalapuram revenue division, 220-700 mg/l in Ramachandrapuram division. Waters with TH more than 300mg/l indicate the hardness and can encrustation on water supply systems and are unsuitable for domestic purposes.

Ca^{2+}: Waters with **Ca^{2+}** concentration 75mg/l can cause encrustation on water supply system and unsuitable for domestic purposes. Ca^{2+} concentration in ground waters during pre monsoon season range from 8-48 mg/l in Amalapuram revenue division, 4-44 mg/l in Ramachandrapuram division. During post monsoon season Ca^{2+} ranges from 16-72 mg/l in Amalapuram revenue division, 16-56 mg/l in Ramachandrapuram division. Ca^{+2} ion concentration in waters is within the permissible limit of drinking water standards [12].

Mg^{2+}: Mg^{2+} ion concentration in ground waters during pre monsoon season range from 9.76-51.24 mg/l in Amalapuram revenue division, 4.88-78.08 mg/l in Ramachandrapuram division. During post monsoon season Mg^{2+} ranges from 29.28-141.52 mg/l in Amalapuram revenue division, 39.04-151.28 mg/l in Ramachandrapuram division. Waters with more than 30mg/l of Magnesium can cause Magnesium Hazard to waters and make the waters unsuitable for irrigation purposes.

Sodium and Potassium (Na^+ & K^+): Sodium ion concentration in ground waters during pre monsoon season range from 3.91-730.4 mg/l in Amalapuram revenue division, 17.29-283.2 mg/l in Ramachandrapuram division. During post monsoon season Na ranges from 11.83-579.1 mg/l in Amalapuram revenue division, 18.87-249 mg/l in Ramachandrapuram division. Waters with Na^+ ion concentration more than 250mg/l (WHO standards) are unsuitable for drinking purposes.

Potassium concentrations in ground water during pre monsoon season ranges from 1.05-33.5 mg/l in Amalapuram revenue division, 0.26-26.51 mg/l in Ramachandrapuram division. During post monsoon season Potassium ranges from 0.9-17.7 mg/l in Amalapuram revenue division, 0.84-57.76 mg/l in Ramachandrapuram division.

Chloride (Cl^-): Chloride level in ground water during pre monsoon season range from 21.27-280.055 mg/l in Amalapuram revenue division, 7.09-304.87 mg/l in Ramachandrapuram division. During post monsoon season Chloride ranges from 21.27-319.05 mg/l in Amalapuram revenue division, 21.27-255.24 mg/l in Ramachandrapuram division. The permissible limit [12] of chloride in drinking water is 250 mg/l and beyond this level the waters lose palatability and become corrosive.

Sulphate (SO_4^{2-}): Sulphate of ground waters during pre monsoon season range from BDL-201 mg/l in Amalapuram revenue division, BDL-109 mg/l in Ramachandrapuram division. During post monsoon season Sulphate ranges from 3.0-130 mg/l in Amalapuram revenue division, 7.0-88.0 mg/l in Ramachandrapuram division. Waters with Sulphate levels within 250 mg/l can be considered for drinking purposes. (Ref-2) and the waters above this permissible limit [12] are not suitable for drinking purposes.

Nitrate (NO_3^-): Nitrate in ground water during pre monsoon season ranges from 0.833-23.77 mg/l in Amalapuram revenue division, 0.78-9.42 mg/l in Ramachandrapuram division. During post monsoon season Nitrate ranges from BDL-22.0 mg/l in Amalapuram revenue division, BDL-18.0 mg/l in Ramachandrapuram division. The Nitrate ion concentration of waters is within the permissible limit[12] (45mg/l) of drinking water standards and hence the waters cannot cause any concern on health of the people.

Phosphate (PO_4^{3-}): Phosphate in ground water during pre monsoon season ranges from BDL-18.9 mg/l in Amalapuram revenue division, 0.8-9.1 mg/l in Ramachandrapuram division. During post monsoon season Phosphate ranges from 1.3-19.2 mg/l in Amalapuram revenue division, 5.4-19.9 mg/l in Ramachandrapuram division. Waters containing Phosphate concentration more than 5mg/l indicate the discharge of agricultural runoffs into the ground water due to the application higher quantities of fertilizers to the surrounding agricultural fields for crop production.

Percent sodium (%Na): %Na during pre monsoon ranges from 7.26-85.46 in water samples of Amalapuram revenue division, 26.17-68.31 in Ramachandrapuram division. During post monsoon season %Na ranges from 10.6-69.6 in Amalapuram revenue division, 11.5-69.3 in Ramachandrapuram division. Waters with %Na level more than the permissible limit [13] of 60mg/l of irrigation standards are unsuitable for irrigation purposes.

SAR: SAR during pre monsoon ranges from 0.17-8.26 in water samples of Amalapuram revenue division, 0.97-9.31 in Ramachandrapuram division. During post monsoon season SAR ranges from 0.41-11 in Amalapuram revenue division, 0.46-7.36 in Ramachandrapuram division. Waters with SAR more than 26 are unsuitable for consideration for irrigation purposes. Ground waters in all the revenue divisions of SAR are observed within the permissible limit [14] and hence can be considered for irrigation purposes.

RSC: RSC during pre monsoon ranges from BDL-0.12 in water samples of Amalapuram revenue division, BDL-0.11 in Ramachandrapuram division. During post monsoon season RSC ranges from BDL in Amalapuram revenue division, BDL-3.88 in Ramachandrapuram division. Waters with RSC less than 1.5me/l are suitable for irrigation purposes [15] waters with RSC more than 1.5me/l are not suitable for irrigation purposes.

Kelly's Ratio (KR): KR during pre monsoon ranges from 0.52-6.98 in water samples of Amalapuram revenue division,0.42-3.84 in Ramachandrapuram division. During post monsoon season KR ranges from 0.12-2.38in Amalapuram revenue division, 0.13-2.5 in Ramachandrapuram division. Waters with KR value of 1 are considered

to be suitable for the irrigation purposes [16]. While the waters with KR with more than 1 are not suitable for irrigation purposes.

MH: MH during pre monsoon ranges from 47.2-91.16 in water samples of Amalapuram revenue division, 28.1-96.9 in Ramachandrapuram division. During post monsoon season MH ranges from 56.5-92.9 in Amalapuram revenue division, 70.3-90.7 in Ramachandrapuram division. Waters with MH less than 50 are suitable for irrigation purposes [17]. Waters with MH more than 50 are with Magnesium Hazard which can deplete the soil quality and in turn the yield of the crops will be reduced in the study areas.

CONCLUSION

pH of ground waters indicate slight saline nature of waters. Waters with EC more than 4000 µmohs/cm are to be considered unsuitable for irrigation purposes. Waters in certain locations with TDS more than 500 mg/l indicate the presence of soluble solids in waters which can change the taste of waters and become unsuitable for drinking purposes. In majority ground water samples collected from Amalapuram division TA is within the permissible limit of drinking water standards while TA crossed the permissible limit in waters collected during post monsoon season from Ramachandrapuram division and change in the taste of waters and make the waters unsuitable for drinking purposes. TH of ground waters during pre monsoon season ar. Within the permissible limit while TH of waters during post monsoon are observed with higher TH values due to percolation of certain solid matter in to ground water sources in the study areas. Calcium ion concentrations in majority waters are within the permissible limit while Magnesium ion concentration in waters of post monsoon crossed the permissible limit of drinking water standards. Sodium and Potassium levels are within the permissible limit of WHO standards. Chloride, Sulphate and Nitrate ion concentrations are within the permissible limits. Phosphate ion concentration in majority waters exceeded the permissible limit of effluent standards (5 ml/l) indicating the discharge of agricultural run-off in to the ground waters.

Percent Sodium, SAR, RSC values are within the permissible limits of irrigation standards. Kelly's ratios of waters in pre monsoon season are within the permissible limit (1) while KR of waters of post monsoon crossed the permissible limits. Magnesium hazard level of waters crossed the permissible limit (50) indicating the Magnesium Hazard of waters which in turn deplete the quality of soil and consequently the crop yields reduce in the study area.

The waters are to be treated properly by using the available techniques like ultra filtration, nano filtration so as to remove the soluble solids and to make waters suitable for drinking to the public residing near agricultural hectic activity areas and also be treated even to consider them for irrigation purposes..

Acknowledgements
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