



RESEARCH ARTICLE

QUALITY EVALUATION OF GROUND WATER NEAR A SALT CREEK BY PHYSICOCHEMICAL CHARACTERIZATION TO ASSESS THEIR POTENTIAL FOR APPLICATION IN VIJAYANAGARAM DISTRICT OF NORTH COASTAL ANDHRA

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ABSTRACT

The present proposed research study is focused on characterization of groundwater collected near a stream joining Bay of Bengal at Konada of Vijayanagaram district of A.P. India to evaluate the status of chemical contamination for assessing their potential for Application. Physicochemical parameters viz., pH, EC, TDS, TH, TA, Ca, Mg, Na, K, F, Cl, SO_4^{2-} and PO_4^{3-} are analyzed along with determination of certain irrigation parameters which include %Na, SAR, RSC, Kelly's Ratio and MH. Standard procedures of APHA and NEERI are followed for the analysis. The research results revealed that the levels of certain physicochemical parameters like EC, TDS, TH, TA, Ca, Mg in majority cases of groundwater exceeded the permissible limit indicating the unsuitability of groundwater for drinking purposes. Irrigation parametric values of %Na, SAR, RSC, KR are within the permissible limit indicating their suitability for irrigation purposes. Magnesium Hazard (MH) levels in majority water samples exceeded the permissible limit indicating the magnesium hazard of these waters. These waters are to properly treated to minimize the levels of MH even for considering them for irrigation purposes or otherwise these waters will deplete the quality of groundwaters and consequently the yield of the crops will be minimized.

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INTRODUCTION

Salt Water intrusion is a natural process which occurs in vertically all coastal aquifers and limited to coastal areas only. It consists of salty water inflow from the sea towards fresh water aquifer and flowing inland. An interface which can be considered as an imaginary line is developed along and earmarks the sea water and fresh water interaction. Salt water encroachment associated with over drafting of aquifers or natural leaching from natural occurring deposits are natural sources of ground water pollution. Presently coastal areas have become densely populated in the world. Nearly half of the population lives in coastal areas and 8 out of 10 largest cities in the world are situated in the coastal line.¹ Sea water intrusions into coastal aquifers lead to impairment of the quality of fresh water aquifers. Intensive withdrawal of ground water followed by significant decrease in recharge contributes to the problem. The degree of saline water intrusion is influenced by the nature of geological settings, hydraulic gradient, rate of ground water withdrawal and its recharge.² Water quality in the coastal aquifers is often threatened by the upcoming of salt water. The salt content of ground water depends on the geological material of the aquifer and the resident time of ground water. In order to determine the causes of ground water salinity and the extent of sea water intrusion due to over pumping, it is important to understand the process of salinization and the mechanism contributing to ground

water salinity.³ Coastal aquifers have site specific characteristics and differ from the characteristic parameters of other aquifers.⁴ Anthropogenic activities which include ground water pumping and reclamation of land one considered to have significant impact on coastal ground water flow both physically and chemically. Sea water intrusion by excessive ground water pumping has been studied extensively.^{5,6,7,8} Ground water is the major source of water for drinking, domestic, agricultural and industrial purposes in many countries. It is estimated that approximately one third of the world's population use ground water for drinking.⁹ The chemical characteristics of ground water play a significant role in classifying and assessing the quality of water. In recent times, attention is being given to study the natural concentration of many ions in ground water to establish the anthropogenic sources which affect the ground water quality. The objective of this present research study is to determine the ground water quality to assess their potential for various applications.

MATERIALS AND METHODS

Ground water samples from 16 bore wells were collected during pre and post monsoon periods. The collected samples were characterized for physicochemical parameters viz., pH, EC, TDS, Na⁺, K⁺, Ca²⁺, Mg²⁺, Cl⁻, HCO₃⁻, NO₃⁻, SO₄²⁻ and PO₄³⁻ by following standard procedures (APHA 10) and the analysis data is presented in tables-2,3&4 respectively.

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Containers made of polythene were employed for sampling of ground water and preserved for analysis as per the standard procedures. Sixteen ground water samples were collected near Konada and analyzed for physicochemical parameters which include pH, EC, TDS, TA, TH, Ca, Mg, Na, K, Chloride, Sulphate and Phosphate.

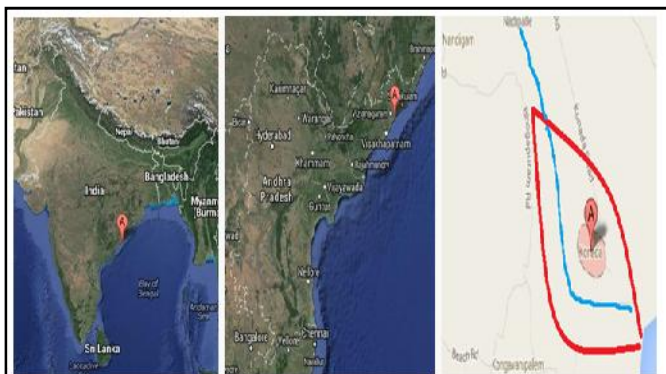


Diagram 1 Study area map

pH determined by pH meter (Global-DPH 505, India – Model) and conductivity measured by the digital conductivity meter (Global-DCM-900-Model), TDS calibrated from the relation $TDS = \text{Electrical conductivity (EC)} \times 0.64$. Total Hardness, Total Alkalinity and Chloride were estimated by Titrimetry. Sulphate, Nitrate and Phosphate measured by Spectrophotometer (Vissican167, Systronics), Na and K by Flame photometry (Systronics). The average value of each parameter characterized during pre monsoon and post monsoon periods were calculated and in turn the average was considered as the parametric value for each parameter. The irrigation parameters Viz., Percent Sodium(%Na), Sodium Adsorption Ratio(SAR), Residual Sodium Carbonate(RSC), Magnesium Hazard(MH), Kelly's Ratio(KR) were calibrated, by employing the following relationship and the analysis data is represented in 3&4 respectively.

Percent Sodium values are expressed in me/l

$$\%Na \text{ (me/l)} = \frac{Na \times 100}{Na + K + Ca + Mg}$$

Sodium Adsorption Ratio values are expressed in me/l

$$SAR \text{ (me/l)} = \frac{Na}{\sqrt{\frac{Ca^{+2} + Mg^{+2}}{2}}}$$

Residual Sodium Carbonate values are expressed in me/l.

$$RSC \text{ (me/l)} = (CO_3^{+2} + HCO_3^-) - (Ca^{+2} + Mg^{+2})$$

Magnesium Hazard values are expressed in me/l.

$$MH = \frac{Mg \times 100}{Ca + Mg}$$

Kelly's Ratio values are expressed in me/l.

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

The Sampling location and sampling code details are presented in table-1

RESULT AND DISCUSSION

pH: pH levels of ground waters collected during pre monsoon season range from 7.14-7.87 while the pH levels of ground water collected during post monsoon season range from 7.06 -

8.48 and all these values are within the permissible limits of drinking as well as irrigation standards¹¹.

Table 1 Sample Code and Sample Location

Sample Code	Sampling Location
W-1	Konada-1
W-2	Konada-2
W-3	Near Shivalayam
W-4	Konada-4
W-5	Konada-5
W-6	Near ZPH School
W-7	Konda-7
W-8	Nadepalli-1
W-9	Nadepalli-2
W-10	Nadepalli -3
W-11	Nadepalli -4
W-12	Konada
W-13	Konada
W-14	Konada
W-15	Konada
W-16	Konada

EC: Waters with EC levels in the range 0-750 $\mu\text{mhos/cm}$ are classified as class-I waters and excellent for irrigation 750-2000 $\mu\text{mhos/cm}$ are classified as class-II and are good but harmful to sensitive crops greater than 2250 $\mu\text{mhos/cm}$ are classified as class-III waters and are unfit for irrigation. EC values of ground water of pre monsoon season range from 1340-7860 $\mu\text{mhos/cm}$. The ground water samples GW-3,7,9,11 are within (750-2000 $\mu\text{mhos/cm}$) and these waters are classified as class-II and these waters are food for irrigation but harmful to sensitive crops. Ground water samples GW-1,2,4,5,6,8,10,12,13,14,15 and 16 are observed with EC values greater than 2000 $\mu\text{mhos/cm}$ and hence these waters are classified as class-III waters and are unsuitable for irrigation purposes¹².

The Ground water samples collected during post monsoon season are observed with EC in the range from 500-5650 $\mu\text{mhos/cm}$. The ground water samples GW-5,6,8,12,13 and 15 are observed with EC values in the range 0-700 $\mu\text{mhos/cm}$ and can be classified as class-I waters and are excellent irrigation purpose. Ground water samples GW-9, 10, 11,13, 14 and 16 are observed with EC levels in the range from 700-2000 $\mu\text{mhos/cm}$ and hence can be classified as class-II waters and are good from irrigation but harmful to sensitive crops. Ground water samples GW-1, 2, 3, 4 are observed with EC values greater than 2000 $\mu\text{mhos/cm}$ and can be classified as class-III waters and are unfit for irrigation purposes.

TDS: Waters with TDS levels in the range 0-700 mg/l are classified as class-I waters and are excellent for irrigation 700-2000 mg/l as class-II and are good for irrigation but harmful to sensitive crops greater than 2000 mg/l are classified as class-III waters and are unfit for irrigation.

Ground water samples collected during pre monsoon season range from 858-5030mg/l ground waters GW-3,5,7,8,9,10,11 and 12 are observed with TDS levels in the range from 700-2000 mg/l and are classified as class-II waters and are good for irrigation but harmful to sensitive crops. Ground water samples GW-1, 2,4,6,12,13,14 and 16 are observed with TDS levels greater than 2000 mg/l and are classified as class-III waters and are unsuitable for irrigation purposes¹².

Ground waters collected during post monsoon season range from 320-3616 mg/l. Ground water samples 5, 6,8,12,13,14,15

Table 2 Konada water samples analysis data

S.Co	pH		EC (μ mhos/cm)		TDS (mg/l)		T.H (mg/l)		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
W-1	7.26	7.31	7860	5650	5030	3616	980	800	208	280	112	24.4
W-2	7.43	8.04	4880	3100	3123	1984	630	500	144	160	66	24.4
W-3	7.79	7.068	1340	2920	858	1868.8	160	600	32	120	19	73.2
W-4	7.25	7.98	4180	2510	2675	1606.4	680	400	120	120	93	24.4
W-5	7.62	8.42	2280	620	1459	396.8	280	500	56	80	34	73.2
W-6	7.47	7.56	4190	500	2682	320	1060	300	128	80	180	24.4
W-7	7.14	8.36	1920	1420	1229	908.8	340	700	88	80	29	122
W-8	7.19	8.48	2280	710	1459	454.4	480	400	64	120	78	24.4
W-9	7.33	7.25	1800	1530	1152	979.2	420	600	88	80	49	97.6
W-10	7.3	8	2530	1100	1619	704	540	500	112	80	63	73.2
W-11	7.83	8.24	1760	1310	1126	838.4	420	600	56	80	44	97.6
W-12	7.48	8.26	3300	560	2112	358.4	600	600	96	40	88	122
W-13	7.51	7.75	3950	730	2528	467.2	700	500	168	120	102	48.8
W-14	7.87	7.66	3720	1040	2381	665.6	1320	600	176	80	107	97.6
W-15	7.24	7.76	2950	700	1888	448	600	400	104	80	63	48.8
W-16	7.45	7.63	3390	1430	2170	915.2	820	300	120	80	73	24.4

Table 3 Konada water samples analysis data

S.Co	T.A (mg/l)		CO ₃ ⁻² (mg/l)		HCO ₃ ⁻ (mg/l)		Cl ⁻ (mg/l)		Fluoride (mg/l)		Na (mg/l)		K (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
W-1	342	800	BDL	200	342	600	461	191	0.38	0.42	98.18	102.54	69.12	46.08
W-2	220	500	BDL	BDL	220	500	191	92	0.42	0.51	47.15	50.26	62.39	32.86
W-3	195	300	BDL	BDL	195	300	71	92	0.47	0.61	16.23	49.61	42.13	11.74
W-4	244	500	BDL	100	244	400	177	35.45	0.52	0.58	45.11	37.04	39.24	18.06
W-5	195	400	BDL	100	195	300	92	35.45	0.54	0.60	31.65	14.26	26.71	2.10
W-6	268	200	BDL	BDL	268	200	191	35.45	0.48	0.52	33.45	10.39	43.90	0.9
W-7	171	600	BDL	200	171	400	92	71	0.51	0.56	14.39	35.21	20.01	0.96
W-8	146	200	BDL	BDL	146	200	92	35.5	0.48	0.58	26.11	14.35	7.32	1.16
W-9	220	200	BDL	BDL	220	200	71	92	0.62	0.60	19.01	22.12	12.10	0.84
W-10	244	300	BDL	BDL	244	300	92	71	0.56	0.54	29.39	20.48	21.47	0.44
W-11	244	200	BDL	BDL	244	200	35.45	71	0.48	0.52	19.72	26.99	6.44	2.03
W-12	220	200	BDL	BDL	220	200	177	92	0.47	0.50	18.32	10.24	16.82	1.12
W-13	220	300	BDL	BDL	220	300	71	92	0.54	0.52	22.42	9.71	20.66	0.81
W-14	220	300	BDL	BDL	220	300	71	92	0.58	0.56	25.67	10.42	20.36	0.94
W-15	220	200	BDL	BDL	220	200	191	35.45	0.60	0.57	31.69	10.63	21.69	0.94
W-16	195	200	BDL	BDL	195	200	177	35.45	0.55	0.62	31.65	18.22	21.71	1.17

Table 4 Konada water samples analysis data

S.Co	Phosphate (mg/l)		Sulphate (mg/l)		Nitrate (mg/l)		%Na(me/l)		SAR (me/l)		Kelly's Ratio (me/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
W-1	4.40	5.3	402	484.3	18.6	21.1	16.64	20.65	1.36	1.58	0.22	0.28
W-2	2.60	3.1	186	199.5	23.5	26.3	12.59	16.84	0.81	0.98	0.16	0.22
W-3	3.24	3.7	292	304.4	19.4	22.4	14.17	15.07	0.56	0.88	0.22	0.18
W-4	BDL	BDL	252	286.5	4.3	6.3	11.80	16.06	0.75	0.81	0.14	0.20
W-5	BDL	BDL	96	115	5.6	7.2	18.01	5.89	0.82	0.28	0.25	0.06
W-6	BDL	BDL	48.6	56.3	7.2	8.1	6.098	7.03	0.44	0.26	0.07	0.08
W-7	BDL	BDL	24.3	36.6	4.9	5.2	7.83	9.99	0.34	0.58	0.09	0.11
W-8	BDL	BDL	62.3	78.8	3.8	4.2	10.33	7.25	0.51	0.31	0.12	0.08
W-9	BDL	BDL	48.6	68.6	5.5	5.4	8.67	7.52	0.40	0.39	0.10	0.08
W-10	BDL	BDL	41.5	52.3	4.8	4.6	10.15	8.28	0.55	0.40	0.12	0.09
W-11	BDL	BDL	96.5	101.7	3.2	3.9	11.56	9.00	0.48	0.48	0.13	0.10
W-12	0.30	0.4	18.6	27.8	11.3	14.5	6.03	3.64	0.33	0.18	0.07	0.04
W-13	BDL	BDL	28.4	35.3	2.6	4.3	5.30	4.08	0.33	0.19	0.06	0.04
W-14	BDL	BDL	21.3	35.5	4.8	6.8	5.82	3.69	0.37	0.19	0.06	0.04
W-15	BDL	BDL	12.0	18	3.9	5.4	11.21	5.51	0.60	0.23	0.13	0.06
W-16	BDL	BDL	49.0	60	5.2	6.1	9.90	11.69	0.56	0.46	BDL	0.13

are observed with TDS levels in the range from 0-700 mg/l and these waters are classified as class-I waters and are excellent for irrigation. Ground water GW-2, 3,4,7,9,10,11,16 are observed with TDS levels in the range 700-2000 mg/l and classified as class-II waters and are good for irrigation but harmful to sensitive crops. Ground water samples GW-1 is observed with TDS level 3616 mg/l greater than 2000mg/l and classified as class-III water and unsuitable for irrigation purposes.

TH: Total Hardness levels of Ground waters collected during pre monsoon season are in the range 160-1320 mg/l. ground water samples 3, 5 are observed with Total Hardness levels within the permissible limits (300 mg/l)¹³ and the other water

samples are observed with Total Hardness levels of higher than the permissible limit.

The Total Hardness levels of ground water samples collected during post monsoon season are observed in the range 300-800 mg/l. Total Hardness of ground water samples 6 and 16 also reached the threshold limit of permissible limit (300 mg/l) and in case of the remaining ground water samples the Total Hardness levels exceeded the permissible limit.

Ca+2: Calcium levels in ground waters during pre monsoon period range from 32-208 mg/l. The ground water samples GW-3, 5, 8, 11 are observed with calcium levels within permissible limit (75 mg/l)¹³ while in case of other ground water samples the Ca levels in water samples of post monsoon

season range from 40-280 mg/l. In case of ground water sample 12 only the calcium level (40 mg/l) is within the permissible limit while in other ground water samples calcium levels exceeded the permissible limit.

Table 4 Konada water samples analysis data

S.Co	RSC (me/l)		MH	
	Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon
W-1	BDL	BDL	46.99	12.24
W-2	BDL	0.048	42.99	19.61
W-3	BDL	BDL	49.37	49.39
W-4	BDL	1.048	56.04	24.55
W-5	BDL	BDL	50	59.42
W-6	BDL	BDL	69.83	32.8
W-7	BDL	BDL	35.2	70.93
W-8	BDL	BDL	66.74	24.55
W-9	BDL	BDL	47.81	66.12
W-10	BDL	BDL	48.05	59.42
W-11	BDL	BDL	56.39	66.12
W-12	BDL	BDL	60.13	82.99
W-13	BDL	BDL	49.97	39.42
W-14	BDL	BDL	50.03	66.12
W-15	BDL	BDL	49.9	49.39
W-16	BDL	BDL	50.04	32.8

Magnesium: Magnesium levels in ground water samples of pre monsoon season range from 19-180 mg/l. Ground water samples 3, 7 are observed with Mg levels within permissible limit (30 mg/l) while Mg levels in other ground water samples exceeded the permissible limit¹³.

Mg levels in ground water samples collected during post monsoon season range from 24.4 -122 mg/l ground water samples GW-1,2,4,6,8 and 16 are observed with Mg levels within the permissible limit while in other samples Mg levels exceeded the permissible limit.

Total Alkalinity(TA): The Total Alkalinity levels of ground waters collected during pre monsoon period range from 146-342 mg/l. Ground water samples-3,5,7,8 and 16 are observed with TA levels within the permissible limit (200 mg/l)¹³. While TA levels of other water samples exceeded the permissible limit. In case of GW samples collected during post monsoon season range from 200-800 mg/l. In majority of the samples TA levels reach the threshold limit of 200 mg/l and exceeded the limit in other samples.

Chloride: Chloride levels of 250mg/l are¹³ suitable for waters for considering them for drinking purposes. In respect of irrigation purposes waters with chloride levels between 0-142mg/l can be classified as class-I waters and can be considered excellent for irrigation waters with chloride levels from 142-355mg/l can be classified as class-II waters and can be considered as good but harmful to sensitive crops. Waters with chloride levels higher than 355mg/l can be classified as class-III waters and are unsuitable for irrigation purposes. Ground waters of Pre Monsoon season are observed with chloride levels ranging from 35.45-461mg/l. All Ground water samples except GW-1 are present within the permissible limits of drinking water standards.

Chloride levels in waters of pre monsoon season GW-1 the chloride level exceeded the permissible limit of irrigation standards(>355 mg/l) and hence unfit for irrigation while in case of other groundwater samples chloride levels range from 35.45-177mg/l and are within the permissible limit. In case of groundwater samples of post monsoon season chloride levels range from 35.45-191mg/l and are within the permissible

limit¹² of drinking water standards. The ground waters are observed with chloride level in the range of 0-142mg/l and hence these waters can be classified as class-I waters and can be considered for irrigation purposes.

Fluoride: The Fluoride levels in groundwater samples collected during pre monsoon samples range from 0.38-0.62mg/l and the Fluoride levels in groundwater samples collected during post monsoon samples range from 0.42-0.62mg/l all these levels are within the permissible limit (1mg/l)¹² of drinking water standards.

Na & K: Sodium levels in ground waters of pre monsoon range from 14.39-98.18 mg/l while Na levels of ground waters of post monsoon season range from 9.71-102.54. Potassium levels of ground water samples of pre monsoon season range from 6.44-69.12 mg/l while K levels in groundwater samples of post monsoon season range from 0.44-46.08mg/l.

Sulphate: Sulphate levels in ground waters of pre monsoon range from 12.0-402 mg/l. In groundwater samples GW-1,3,4 the levels exceeded the permissible limit(250 mg/l)¹³ while in other samples sulphate levels are within the permissible limit. The sulphate levels in groundwater of post monsoon season range from 18-484.3 mg/l. In ground water samples GW-1, 3, 4 the sulphate levels exceeded the permissible limit while in other samples sulphate levels are within the permissible limit.

Nitrate: Nitrate levels in ground water samples collected during pre monsoon season range from 2.6-23.5 mg/l while in Nitrate levels in ground waters of post monsoon samples range from 3.9-26.3 mg/l and all the levels are within the permissible limit¹³ of drinking water standards.

Phosphate: Phosphate levels in ground waters of pre monsoon season in majority of samples are observed at Below Detectable Limit (BDL) while only in samples GW-1,2,3,12 the levels are observed at 4.40,2.60,3.23 and 0.30 mg/l respectively. The phosphate levels in ground waters of post monsoon season in GW-1,2,3 and 12 are observed at 5.3,3.1,3.7 and 0.4 mg/l respectively while in other waters phosphate levels are observed at BDL.

%Na: Waters with Percent Sodium levels below 60 me/l can be considered for irrigation purposes¹⁴. Ground waters collected pre monsoon season are observed with Percent Sodium levels range from 5.30-16.64 me/l and are within the permissible limit. In case of ground waters collected during post monsoon season the Percent Sodium levels range from 3.64-20.65 me/l and these levels are also within the permissible limit of irrigation standards and hence these waters can be considered for irrigation purposes.

SAR: Waters with SAR values within 26 me/l can be considered for irrigation purposes. Ground waters collected during pre monsoon season are observed with SAR values range from 0.33-1.36 me/l while SAR levels in ground waters collected during post monsoon season are observed with SAR values range from 0.18-1.58 me/l and all these levels are within the permissible limit¹⁵ and can be considered for irrigation purposes.

Residual Sodium Carbonate (RSC): Waters with RSC value <1.25 are safe for irrigation. Waters with RSC from 1.25-2.50 are to be used with caution. Waters with RSC values greater than 2.50 are unsuitable for irrigation. RSC levels of ground waters collected during pre monsoon period are observed at

BDL; while RSC values in case of post monsoon samples GW-2 and GW-4 are 0.048 and 1.048 me/l and the levels are within the permissible limit and less than 1.25 me/l and can be considered safe for irrigation while in other water samples RSC values are observed at BDL and hence these waters can be considered for irrigation¹⁶.

Magnesium Hazard (MH): Waters with Magnesium hazard levels less than 50 can be considered for irrigation¹⁷. Ground waters collected during pre monsoon period are observed MH levels range from 35.2-69.83. Ground water samples GW-1,2,3,7,8,9,13 and 15 are observed with MH levels less than 50 and hence these waters can be considered for irrigation. While in other samples GW-4, 5, 6, 8, 11, 12, 14 and 16 MH levels exceeded the permissible limit and hence these waters are not suitable for irrigation. The MH levels in ground waters collected during post monsoon season are observed with MH levels range from 12.24-82.99. MH levels in GE-1, 2, 3, 4, 6, 13, 15 and 16, are less than 50 and hence can be considered for irrigation. MH levels in waters GW-5,7,9,10,11,12,13 and 14 exceeded the value of 50 and hence these waters are observed with Magnesium Hazard and hence these waters can be considered for irrigation purposes.

Kelly's Ratio: Waters with Kelly's Ratio less than 1 can be considered for irrigation purposes^{18, 19} ground waters collected during pre monsoon period are observed with KR values range from 0.06-0.22 while KR values of ground waters collected during post monsoon period ranges from 0.04-0.28 and all these values are within the permissible limit and hence these waters can be considered for irrigation purposes.

CONCLUSIONS

pH values of ground waters in both pre and post monsoon period indicate slight to moderate alkaline nature. Electrical conductivity levels in majority pre monsoon groundwater samples indicate saline nature due to their classification of class-III waters which are unsuitable for irrigation. While majority of samples in post monsoon period due to their classification as class-II and class-III and may not be suitable for irrigation purposes. TDS levels in majority of samples indicate the presence of soluble solids in waters making the waters unsuitable for drinking purposes. The TDS levels further revealed that majority waters are unsuitable for irrigation purposes also.

Total Hardness levels also indicate the hardness of these ground waters and hence these waters are not suitable for domestic purposes as these waters can cause encrustation to the water supply systems. Calcium levels in majority water samples exceeded the permissible limit and can cause encrustation in water supply systems. Magnesium levels in majority water samples also indicate the magnesium hazard of these waters and hence these water are not suitable for irrigation purposes.

Total Alkalinity values in majority of samples exceeded the permissible limit indicating their unsuitability for drinking purposes. Chloride levels in majority of groundwater samples are permissible limit (250mg/l) of drinking water standards; however majority water samples though good for irrigation but harmful to sensitive crops. Fluoride levels are within the permissible limit. Nitrate and Phosphate and Sulphate levels in majority of water samples are within the permissible limits.

Percent Sodium levels are within the permissible limit (26me/l) indicating the suitability of waters for irrigation purposes. Sodium Adsorption Ratio (SAR) levels are also within the permissible limit (26me/l) indicating the suitability of these waters for irrigation purposes. Kelly's Ratio of these waters is also within the permissible limit indicating the suitability of waters for irrigation. RSC values of waters are within the permissible limit indicating the suitability of waters for irrigation. But Magnesium hazard level in nearly 50% of water samples exceeded the permissible limit (50) indicating the unsuitability of these waters for irrigation purposes.

The studies concluded that higher levels of physicochemical parameters indicate the chemical contamination of these groundwater confirming their unsuitability for drinking purposes. Ground waters at some places are observed with higher levels of magnesium hazard indicating their unsuitability irrigation as the higher levels of MH deplete the soil quality and consequently the yield of the crops will be minimized. Proper treatment techniques are to be proposed to be implemented to enhance these waters even for considering them for irrigation purposes.

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