

HYDROCHEMICAL ANALYSIS OF GROUND WATER OF RAMPURHAT-II BLOCK, BIRBHUM DISTRICT, WEST BENGAL, INDIA

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ABSTRACT

The purpose of this study is investigating the chemical analysis of groundwater in Rampurhat-II block of Birbhum district, West Bengal, India. Altogether 24 representative groundwater Samples were collected from borewells and tubewells, during March 2010 in order to assess its suitability for drinking as well as irrigation purpose. The water chemistry of samples were analyzed for pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), Sulphate (SO_4^{2-}), Nitrate (NO_3^-), phosphate (PO_4^{3-}), Fluoride (F^-), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^+), Potassium (K^+), Bicarbonate (HCO_3^-), carbonate (CO_3^{2-}), chloride (Cl^-) and Total Hardness (TH) using standard techniques. The results revealed that the maximum SAR (Sodium adsorption ratio) in the study area was 0.87 i.e, below 1. RSC (Residual sodium carbonate) value among the samples is maximum 0.844 which is below 1.25 meq/l, indicating no sodium carbonate hazard in the study area. % Na values indicating its suitability for irrigation. But in most of the water samples some parameters like EC, Ca^{2+} , Na^+ were above the acceptable limit recommended by WHO. pH ranged in all the samples within the limit (6.5 to 8.5). Based on the findings of this study, it can be expressed that the groundwater quality in Rampurhat-II block is suitable for irrigation but not appropriate for drinking as some of the parameters are elevated and need proper treatment. Although Birbhum district is one of the worst fluoride affected district in West Bengal the fluoride concentration was within the permissible limit i.e. 1.5 mg/l in all samples.

Keywords: Groundwater quality, Rampurhat-II block, Birbhum district, West Bengal, India.

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INTRODUCTION

The quality of water is vital for humankind. Some of the natural and anthropogenic processes are very important for modification of groundwater quality like oxidation/reduction, cation exchange, dissociation of minerals, precipitation of secondary minerals, mixing of waters, leaching of fertilizers and manure, pollution and lake/sea, biological processes.¹ Poor quality of water adversely affects the human, animal and plant health.²⁻⁷ Groundwater quality data is essential to determine the origin of the chemical composition of groundwater.⁸ The Rampurhat II block under Birbhum district, West Bengal is predominantly a poor rural area with a significant tribal population. Agriculture is the main source of livelihood. Moreover, it lies in the semiarid zone of West Bengal.⁹ Thus groundwater quality mainly influenced by lithology and fertilizers used for agricultural purposes (leached with precipitation). The purpose of our present study is to study the groundwater quality of Rampurhat II block and to evaluate its suitability for drinking and irrigation.

Study Area

Rampurhat II is a rural area of Birbhum district, West Bengal, India. The coordinates are 24°10'34''N 87°52'56''E having an area of 184.22 Km². The groundwater samples were collected from Kabirajpur, Mountain, Dunigram and Modhupur villages.

As per 2001 census, Rampurhat II block had a total population of 158,756, out of which 81,973 were males and 76,783 were females. The density of population is 862/Km². The tribal population numbered 1081. During 1991 – 2001 decade population growth rate was 14.64%.

Rampurhat II block climatologically falls under the western semi-arid belt of West Bengal. The summer is severe with an average temperature of 40°C. During the month of May temperature shoots up to 48°C. The average temperature is 10°C in winter, but temperature as low as 6°C is also recorded. This area receives rainfall from mid-June to September and sometimes up to October.

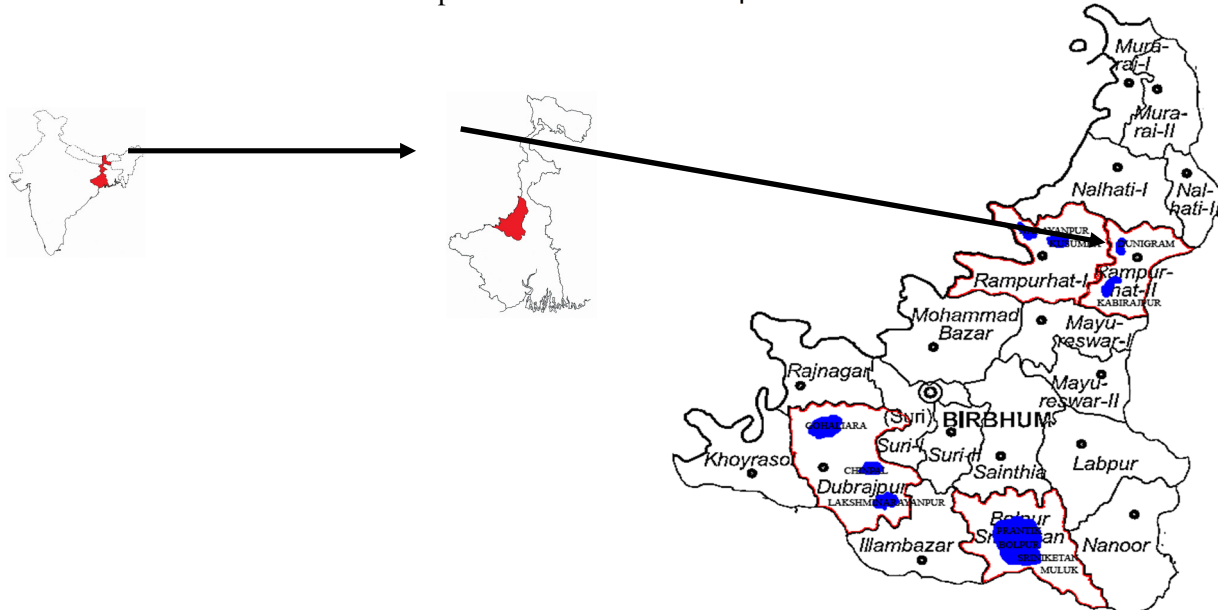


Fig.-1 Map showing the location of study area

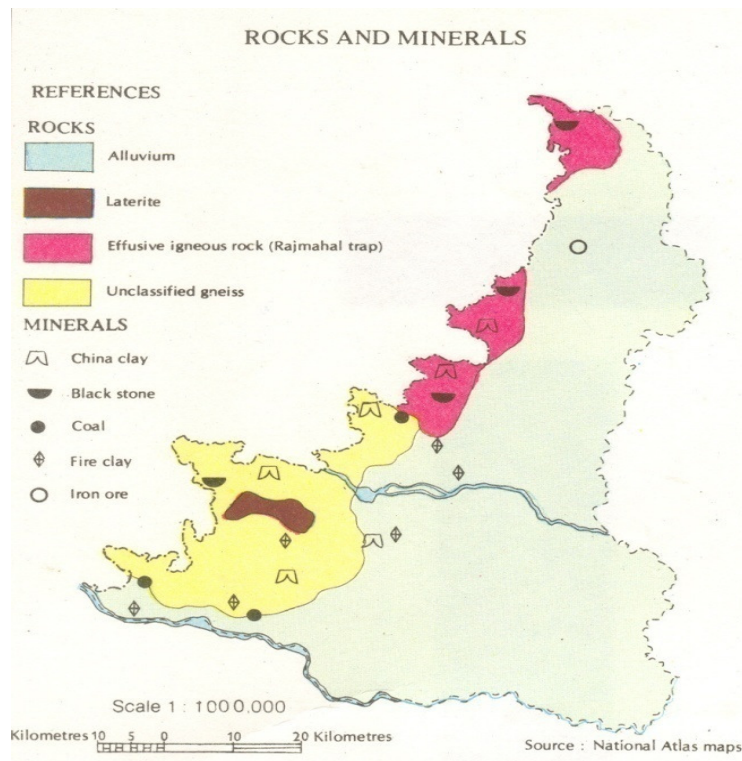


Fig.-2: Map showing the geology of the study area

Geology

Geology of an area plays a very important role in the concentration of different chemical parameters of groundwater of an area. Rampurhat II block lies in the north east of Birbhum district. Mainly Gondwana overlay by Rajmahal trap (Basalt) occurring in the northern part of the district but some parts is occupied by Laterite. Rampurhat II is characterized by Older Alluvium (Rampurhat Formation). Hard clay impregnated with Caliche nodules of Rampurhat Formation in east and northeast of this district overlain by alternating layers of sand, silt, and clays of Kandi Formation of Quaternary age. In alluvial tracts (sand, silt, clay) the depth to water table in May-June is 2m to 16m.

EXPERIMENTAL

From Rampurhat II block 19 tubewell and 5 borewell samples were collected from Kabirajpur, Mountain, Dunigram and Modhupur villages along with GPS during March, 2010. The parameters include Temperature, pH, EC, Total hardness, TDS, cations like Ca^{2+} , Na^+ , K^+ , Mg^{2+} and anions like HCO_3^- , CO_3^{2-} , NO_3^- , PO_4^{3-} , SO_4^{2-} , Cl^- . Temperature, pH was measured in field pH meter and Orion ion selective electrode. Electrical conductivity, fluoride, chloride, and nitrate were measured in Orion ion selective electrode (Model Meter 1119000). Ca^{2+} , Na^+ , K^+ was measured using ELICO CL 361 Flame Photometer. TDS was measured in SYSTRONICS –TDS meter (Type no. 308). HCO_3^- , CO_3^{2-} was measured using the titrimetric method. phosphate was measured by stannous chloride method and sulfate by the turbidimetric method. Hardness and magnesium were estimated by standard methods.¹⁰ SAR (Sodium adsorption ratio), RSC (Residual sodium carbonate) and %Na was calculated using standard formula.^{2,11-13}

$$\text{SAR} = \text{Na}^+ / \{(\text{Ca}^{2+} + \text{Mg}^{2+}) \div 2\}^{1/2}$$

$$\% \text{Na} = (\text{Na}^+) \times 100 / (\text{Ca}^{2+} + \text{Mg}^{2+} + \text{Na}^+ + \text{K}^+)$$

$$\text{RSC} = (\text{HCO}_3^- + \text{CO}_3^{2-}) - (\text{Ca}^{2+} + \text{Mg}^{2+})$$

All the ionic concentrations are expressed in ppm. Correlation coefficients, mean and standard deviation of the chemical parameters were analyzed statistically.

RESULTS AND DISCUSSION

The summary of the obtained range of concentrations of physicochemical parameters of water samples is given in Table-1. In this table, the minimum and maximum concentration of major ions of the groundwater samples along with a statistical summary and official safe limits for drinking water are given. The classification of water samples on the basis of EC is given in Table- 2 and the classification of rampurhat II water samples based on hardness by Sawyer and Mc Carthy is given in Table-3. In Table -4 the water samples of the study area exceeding the desirable limits prescribed by WHO for domestic purposes are given. Classification of water samples based on %Na are given in Table-5 which shows that the irrigation quality of the Rampurhat II samples is excellent to good. The statistical correlation coefficient of major ions is described in Table- 6. Obtained results of physicochemical analysis of water quality parameters are given in Table-7.

Table-1: Statistical Summary of Water Sample Quality of Different Sources of Rampurhat-II Block

Ions	Rampurhat-II Samples				Max. acceptable limits(WHO)
	Min.	Max.	Mean	Std. Deviation	
Na^+	17.1	28.2	22.85	2.468	20
K^+	0.06	1.4	1.015	0.352	20
Ca^{2+}	48.67	115.8	75.83	16.165	75
Mg^{2+}	4.86	12.1	8.615	2.39	50
CO_3^{2-}	0	0	-	-	350
HCO_3^-	200	286	245.37	25.85	384

SO ₄ ²⁻	8.36	119.34	50.813	25.55	400
NO ₃ ⁻	0.91	7.15	4.638	1.97	10
PO ₄ ³⁻	0.032	0.071	0.0485	0.01	5
F ⁻	0.211	0.363	0.3	0.035	1.5
Cl ⁻	10	15	11.67	1.816	250
EC	526	905	807.37	74.1	300
TH	110	151	132.47	12.38	500
TDS	264	453	404.25	36.95	1000
pH	7.2	7.41	7.323	0.066	6.5-8.5
TEMP.	27.2	28	27.6	0.204	

EC values are expressed in $\mu\text{S}/\text{cm}$ and Temperature in $^{\circ}\text{C}$. Rest of the parameters are expressed in mg/l . In Rampurhat II samples the pH ranged from 7.2 to 7.41 indicating neutral to slightly alkaline nature which may be due to feldspar releasing sodium and calcium. For drinking water 300 $\mu\text{S}/\text{cm}$ is the permissible limit for EC and it was found to be elevated in all the Rampurhat II samples.

Table-2: Classification of All Groundwater Samples Based on Electrical Conductivity (WHO) for Agricultural Purposes

EC($\mu\text{S}/\text{cm}$)	Classification	No. of Rampurhat 2 sample
< 1500	Permissible	24
1500-3000	Not permissible	Nil
>3000	Hazardous	Nil
Total sample		24

Among the Rampurhat II samples as the range of EC was 526- 905 $\mu\text{S}/\text{cm}$, all are permissible for irrigation purposes. Among Rampurhat II samples the TDS value ranges from 264- 453 mg/l thus all within permissible limit. Fluoride, sulfate, phosphate, magnesium, chloride, potassium, nitrate and bicarbonate concentrations are also within permissible limit (Table-7)

Among Rampurhat II samples TH was found to be within the permissible limit (110- 151 mg/l) according to WHO⁵. The classification of these samples according to Sawyer and Mc Carthy¹⁴ is given in Table-3 which shows that 45.84% samples of Rampurhat II block falls under moderate hard category and rest samples were soft. CO₃⁻² was not traced in any Rampurhat II sample.

Table -3: Classification of Rampurhat II Water Based On Hardness by Sawyer and Mc Carthy

Hardness and Water Class CaCO ₃ (ppm)	Rampurhat II samples	
0-75	Soft	13 samples
75-150	Moderate hard	11 samples(78.63 – 115.8 mg/l)
150-300	Hard	0 samples
>300	Very hard	0 samples

Table -4: Groundwater Samples of the Study Area Exceeding the Desirable Limits Prescribed by WHO For Domestic Purposes

Water quality parameters	WHO 1997, desirable limits	No. of Rampurhat II samples exceeding desirable limits	Undesirable effects
pH	6.5-8.5	Nil	Taste
EC($\mu\text{S}/\text{cm}$)	300	19 TW, 5BW	
TDS(mg/l)	500	Nil	Gastrointestinal irritation
TH(mg/l)	500	Nil	
Na ⁺ (mg/l)	20	17TW, 5BW	Elevated blood pressure
K ⁺ (mg/l)	20	Nil	Bitter taste
Ca ⁺ (mg/l)	75	9TW, 2BW	Scale formation

Mg ⁺ (mg/l)	50	Nil	
CO ₃ ⁻² (mg/l)	350	Nil	
HCO ₃ ⁻ (mg/l)	384	Nil	
SO ₄ ⁻² (mg/l)	400	Nil	Laxative effects
NO ₃ ⁻ (mg/l)	10	Nil	Blue baby
PO ₄ ⁻ (mg/l)	5	Nil	
F ⁻ (mg/l)	1.5	Nil	Fluorosis
Cl ⁻ (mg/l)	250	Nil	Salty taste

Calcium was found to be above the permissible limit in 40% borewell samples and 47.368% tubewell samples (Table-7). Na⁺ was found to be elevated in 100% deep tubewell and 89.47% shallow tubewell samples.

RSC : The maximum RSC value of Rampurhat II groundwater samples was found to be 0.844 meq/l (Dunigram t11) which is less than 1.25 meq/l indicating no bicarbonate hazard in the study area.

SAR : The maximum SAR value was found to be 0.87 (Modhupur t17) which is much below the permissible limit, indicating no sodium hazard in the study area.

Percentage Na : Table-5 shows that the irrigation quality of the Rampurhat II samples is excellent to good.

Table-5: Irrigation Quality of Rampurhat II Groundwater Based on % Na

% Na	Classification	No. of Rampurhat II samples
< 20	Excellent	18
20 - 40	Good	6 (1BW, 5TW)
40 - 60	Permissible	0
60 - 80	Doubtful	0
> 80	Unsuitable	0

Table -6: Correlation Coefficients of the Chemical Parameters of Groundwater Samples of Rampurhat II Block

	pH	EC	TDS	F ⁻	TH	NO ₃ ⁻	SO ₄ ²⁻	PO ₄ ³⁻	Ca ²⁺	Na ⁺	K ⁺	Mg ²⁺	Cl ⁻	HCO ₃ ⁻
pH	1	0.211	0.213	-0.3	-0.02	0.085	0.581	0.112	0.558	-0.21	-0.114	-0.184	-0.072	0.257
EC		1	0.99	-0.02	0.05	0.078	0.151	0.06	0.14	-0.35	-0.48	0.05	0.13	0.01
TDS			1	-0.02	0.049	0.078	0.149	0.064	0.138	-0.355	-0.477	0.052	0.125	0.012
F ⁻				1	-0.26	-0.057	-0.397	-0.184	-0.328	0.075	-0.177	-0.2	-0.255	-0.255
TH					1	0.035	0.25	0.194	0.22	-0.23	-0.24	0.79	0.243	0.28
NO ₃ ⁻						1	-0.153	0.248	-0.029	-0.316	-0.167	-0.065	0.21	-0.105
SO ₄ ²⁻							1	-0.069	0.864	-0.278	-0.368	0.183	-0.008	0.219
PO ₄ ³⁻								1	0.09	-0.168	-0.085	0.046	-0.24	0.182
Ca ²⁺									1	-0.295	-0.306	-0.002	0.0013	0.001
Na ⁺										1	0.637	-0.22	-0.003	0.05
K ⁺											1	-0.213	-0.15	0.078
Mg ²⁺												1	0.025	0.002
Cl ⁻													1	-0.126
HCO ₃ ⁻														1

Table-7: Physicochemical Analysis of Water Quality Parameters of Rampurhat-II Block

Sample	TEMP (°C)	PH	F ⁻ (mg/l)	EC (µs/cm)	TDS (mg/l)	Cl ⁻ (mg/l)	TH (mg/l)	Mg ²⁺ (mg/l)	HCO ₃ ⁻ (mg/l)	SO ₄ ²⁻ (mg/l)	NO ₃ ⁻ (mg/l)	PO ₄ ³⁻ (mg/l)	Ca ²⁺ (mg/l)	Na ⁺ (mg/l)	K ⁺ (mg/l)
Ka t1	27.8	7.37	0.287	526	264	11	130.5	7.91	240	65.9	3.04	0.048	78.66	24.6	1.4
Ka t2	27.4	7.25	0.316	729	365	10	135	8.1	265	61.4	4.65	0.05	86.95	22.1	1.2
Mo t3	27.7	7.31	0.289	881	441	11	128.7	9.71	210	56.8	5.61	0.061	66.66	20.5	1
Mo t4	27.2	7.36	0.33	892	446	14.5	131	8.02	220	69.56	4.85	0.041	78.63	22.1	0.6

Mo t5	27.5	7.3	0.3	806	403	15	140	8.89	280	73.52	6.45	0.04	99.7	21.6	0.7
Mo t6	27.9	7.4	0.324	854	427	10	120	9.6	204	70.5	6.5	0.036	73.7	17.1	0.2
Mo t7	27.6	7.3	0.284	885	443	12	151	9.72	255	67.4	3.36	0.071	87.48	19	0.06
Mo t8	27.7	7.41	0.283	866	434	11.5	146	10.1	286	58.6	7.15	0.064	90.02	23.6	0.9
Mo t9	28	7.28	0.283	798	399	12	135	9.93	200	70.51	5.88	0.044	89.5	22.1	1
Du t10	27.5	7.32	0.319	816	409	10.5	110	4.9	220	28.6	2.91	0.05	61.02	24.8	1.4
Du t11	27.4	7.29	0.335	821	411	10	115	4.86	260	15.6	5.89	0.038	60.47	22.4	1.2
Du t12	27.5	7.41	0.309	848	425	10	128	6.8	245	31.6	6.54	0.07	71.2	21.6	1.1
Du t13	27.7	7.37	0.245	784	393	11	164	15.2	264	71.32	6.45	0.055	80.04	22.2	1.2
Du t14	27.5	7.23	0.307	798	399	15	156	11.6	220	8.36	4.94	0.041	48.67	20.5	1
Du t15	27.6	7.31	0.309	811	406	14.6	130	7.4	235	14.4	5.62	0.036	50.02	26.1	1.4
Modt16	28	7.46	0.272	905	453	12	135	7.9	280	119.34	1.24	0.032	115.8	22.9	0.9
Modt17	27.7	7.26	0.335	787	394	10	130	9.1	240	46.4	2.68	0.045	65	28.2	1
Modt18	27.7	7.29	0.363	751	376	10	125	6.31	255	28.9	6.1	0.056	70.78	25.3	1.2
Modt19	27.4	7.23	0.331	792	397	12	125	8.91	260	21.41	6.14	0.052	72.3	21.9	0.8
DuT1	27.4	7.2	0.312	801	402	10	135	12.1	225	31.19	0.91	0.036	49.9	26.1	1.2
DuT2	27.4	7.3	0.267	809	404	12	128	10.2	265	42.3	1.08	0.053	73.85	23.8	1.4
Du T3	27.5	7.4	0.349	817	409	10	136	8.03	280	56.4	1.8	0.046	89.11	22.1	1
Ka T4	27.7	7.35	0.246	784	393	15	120	5.04	220	48.2	6.11	0.049	71.66	25.9	1.1
KaT5	27.8	7.37	0.211	816	409	11	125	6.44	260	61.3	5.42	0.051	88.77	21.9	1.4

T= borewell sample, t= tubewell sample; Ka= Kabirajpur, Mo= Motain, Du=Dunigram, Mod=Modhupur

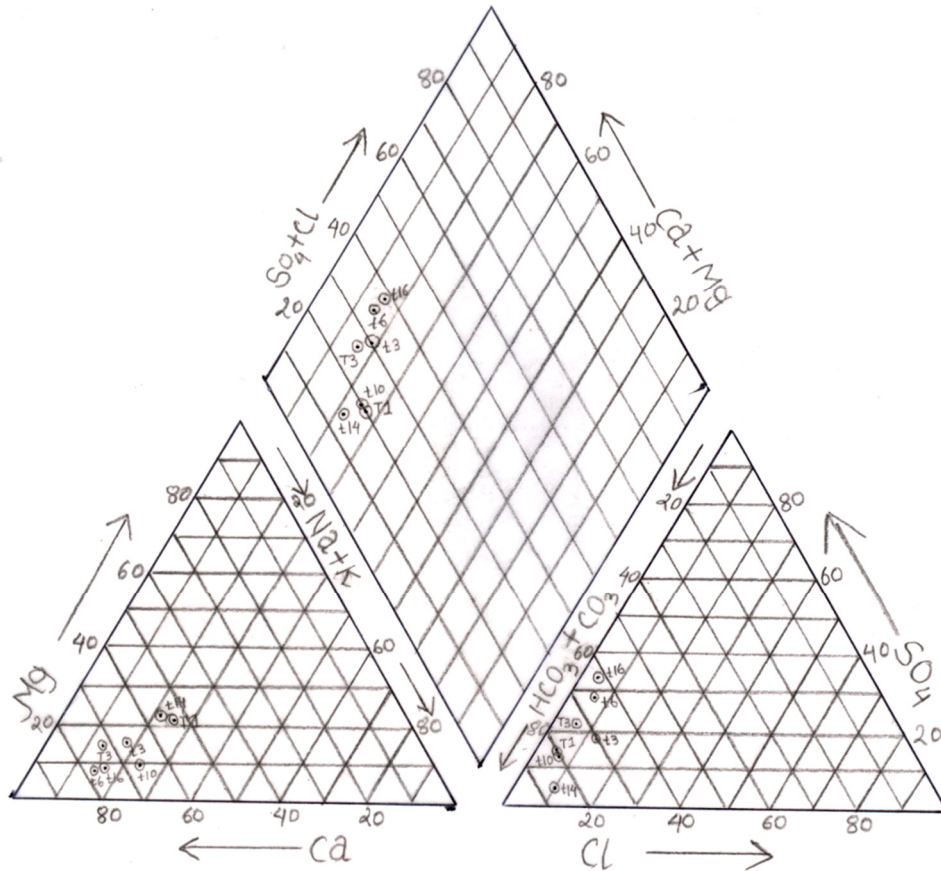


Fig.-3: Piper diagram showing the hydrogeochemical facies of Rampurhat II block

Fig.-3 shows that in Rampurhat II block all samples are $\text{SO}_4 + \text{Cl}$ type Ground water with a base exchange reaction in which the alkaline earths have been exchanged for Na^+ ions ($\text{HCO}_3^- > \text{Ca}^{2+} + \text{Mg}^{2+}$) may be referred to as base-exchanged-softened water, and those in which the Na^+ ions have been exchanged for the alkaline earths ($\text{Ca}^{2+} + \text{Mg}^{2+} > \text{HCO}_3^-$) may be referred to as base-exchanged-hardened water.¹⁵ In Rampurhat II groundwater samples $\text{HCO}_3^- > \text{Ca}^{2+} + \text{Mg}^{2+}$ was observed in 20.83% samples (4 tubewells, 1 borewell sample) i.e, base-exchanged-softened water. All of these base-exchanged-softened water was observed in Dunigram village (t10, t11, t14, t15 and T1) samples. Rest 79.17% samples were base-exchanged-hardened water ($\text{Ca}^{2+} + \text{Mg}^{2+} > \text{HCO}_3^-$)

CONCLUSION

From the obtained results it can be concluded that groundwater of the study area is suitable for irrigation but not for drinking.

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