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Suitability evaluation of groundwater for irrigation purposes: A study on tea garden belts villages of Golaghat District, Assam, India

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ABSTRACT

A study was carried out to assess the quality of underground water for irrigation purposes in the tea garden belts of Golaghat district of Assam, India. A total of 30 groundwater samples were analyzed for pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Chloride Fluoride, Hydrogen Carbonate, Nitrate–Nitrogen, Sulphate, Phosphate, Sodium, Potassium, Calcium, Magnesium, Boron and Iron. In addition to assess the water quality for irrigation purposes sodium adsorption ratio (SAR), soluble sodium percentage (SSP) and residual sodium carbonate (RSC) were calculated using standard equations. The concentration of Ca, Mg, Na, K, Cl^-, F^-, NO_3-N, SO_4^{2-}, HCO_3^- and Fe in water samples were within the permissible range of drinking purposes. The calculated kurtosis values for Ca, Mg, Na, K, B, Fe, Cl^-, F^-, NO_3^--N, SO_4^{2-}, HCO_3^- and PO_4^{3-} are less than 3 (β_2<3). For pH kurtosis was found in normal distribution curve (β_2=3) whereas for EC the curve is mesokurtik (β_2 >3). The SAR value ranges from 1.02 to 24.14. Out of 30 sampling stations 26 station's SAR are found excellent for irrigation (SAR<10), two station falls in good class (SAR=10-18) and other two falls in medium class. The study revealed that more than 50% water samples are not suitable for irrigation purposes (RSC > 1.25). The range of SSP% was recorded 6.78-70.07. SSP% for ten stations found in excellent category (SSP% <20), fifteen stations in good category (SSP%= 20-40) and others are medium to vary bad category.

Key words: Underground water quality, irrigation purposes, SAR, SSP, and RSC.

INTRODUCTION

Developments and population growth have increased the demand of all kind of water sources for domestic, irrigation and industrial consumption globally. Water is the most crucial inputs required for plant growth in agricultural production [Sindhu, 2010]. In general natural rainfall replenishes soil water storage in plant root zone at an optimum level to get higher yield but alone it is an inadequate and undependable source of irrigation in arid and semi-arid climate like

Assam, India. Therefore groundwater resources being extensively use to meet the growing demand and are going to rise in the coming years.

Ground water is the major source of irrigation water in the tea gardens of Golaghat district of Assam, India. Injudicious use of agro-chemicals and pesticides in the tea gardens has intensified problems in environmental pollution particularly on soil and water environment. While the usage of chemical fertilizers as lead to increased in tea production, the impact on tea quality and soil and water environment through physical, chemical and biological changes haven't considered relevant until the last 15 years [Madhab, 2004]. The chemical parameters of water play a significant role in assessing its suitability for agricultural purposes [Sadashivaiah *et al*., 2008]. Hence the study has focused on evaluation of groundwater for its suitability for irrigation. A total of 30 ground water samples were analyzed for pH, electrical conductance (EC), total dissolved solids (TDS), chloride, fluoride, bicarbonate, nitrate–nitrogen, sulphate, phosphate, sodium, potassium, calcium, magnesium, iron and boron. The quality of ground water was interpreted in terms of sodium adsorption ratio (SAR), soluble sodium percentage (SSP) and residual sodium carbonates (RSC).

MATERIALS AND METHODS

Study Area

Golaghat district of Assam is cartographically confined with latitudes of $25^0 45^/$ N and $27^0 10^/$ N and Longitudes of $93^0 30^/$ E and $94^0 22^/$ E with a total geographical area of 3502 sq. kms. It is bounded in the north by Sonitpur District on the east by Jorhat District on the south Karbi Anglong and Nagaon District and the west by Nagaland. Climatically it falls in the Upper Brahmaputra Valley Agro-Climatic Zone and enjoys monsoon type of climate. The average annual rain fall recorded is about 983mm and 1085 mm in the year 2007 and 2008 respectively. But the cumulative rainfall was deficient by 27% in the year 2009. Geologically this district falls in the hard pre-cambrian formations. This hard pre-cambrian is overlain by tertiary rich in mafic minerals. In these formations ground water occurs under semi-confined condition to confined condition within the depth range of 2 to 7 meter below ground level.

Work Plan

To study the existing scenario of ground water quality of the tea garden belts villages of Golaghat district with respect to physicochemical indicators, water samples were collected from selected tea garden belts villages only. In the present study covers four tea estate belt (TE) viz. Rungagora, Borjan, Negheriting and Khomtai TE. Water samples were collected from Tube Well (depth up to 80 fts) and Deep Tube Well (depth up to 130 fts). A total of 30 water samples (18 from Tube Wells and 12 from Deep Tube Wells) were collected from four tea gardens belts depending upon the availability of the sources.

Water Sample Collection and Analysis

The study was carried out during November, 2009 to March, 2010. Tube Wells and Deep Tube Wells were operated at least three minutes before collection of the water samples in two different 1L plastic containers. 1:1 HNO_3 solution was added to one of the container to make the pH less than 2 at the time of sampling for metal estimation viz. Na, K, Ca and Fe. The water quality parameter estimation and calibration of equipments were done using standard methods and techniques APHA, AWWA, WPCF (1989); Trivedy and Goel, (1986). The pH of water sample was determined with a digital pH-meter (Eutech, Model-356C). The ions present in water were also analyzed by conductometric titrations (ATC, Model 975-C). TDS were estimated using evaporation method. Sodium and potassium samples were analyzed by flame photometer

(Labtronics, Model LT- 34) using standard calibration procedure. Calcium and magnesium were determined by complexometric titration. Iron in the water samples were determined by spectrophotometrically using phenanthroline method (Hitachi, 3210). Sulphate was determined tubidimetrically. Alkalinity and hydrogen carbonate was by estimated by titration method. Chlorides were estimated by argentometric method. Phosphate and boron were estimated by colorimetrically. Nitrates in water samples were estimated by UV Screening spectrophotometer Method. Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP) and Residual Sodium Carbonate (RSC) were calculated using following standard formulae.

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}};\ SSP = \frac{Na^+}{\left(Na^+ + K^+ + Ca^{2+} + Mg^{2+}\right)} \times 100$$

$$RSC = \left(CO_3^{2-} + HCO_3^-\right) - \left(Ca^{2+} + Mg^{2+}\right)$$

Statistical analyses were done utilizing the Statistical Package for the Social Sciences (SPSS-Version13.0).

Table *1*: List of Sampling Location, Sample Numbers, Sources and Sample Types

Sampling Location	No of Samples	Sample Source
Rungagora TE	10	TW-7, DTW-3
Borjan TE	5	TW-3, DTW-2
Negheriting TE	6	TW-3, DTW-3
Khomtai TE	9	TW-8, DTW-1
Total	30	TW-18, DTW-12

TE- Tea Estate, TW- Tube Well, DTW- Deep Tube Well

RESULTS AND DISCUSSION

During study periods the average rainfall, temperature and relative humidity were recorded 47.52-267.34 mm, 10.97-28.34^{0}C and 49.14-82.34% respectively. The quality of ground water for irrigation purposes was ascertained mainly on the basis of chemical composition of major ions present in it. Descriptive statistics of chemical constituents of collected ground water samples are presented in the **Table 2** and **Table 3.** Range of pH and EC were recorded 6.23-8.02 and 0.0892-0.4129 dS/m respectively. The study revealed that all water samples collected for analysis were found within permissible limit (6.5 to 8.4). Five samples were reported pH less than 6.5 in Negheriting TE. No water salinity hazard was found in this study; only 5% water samples were found excellent (EC $\leq$ 0.25 dS/m) and others were in good class (EC= 0.25 - 0.75). The calculated kurtosis values for Ca, Mg, Na, K, B, Fe, Cl^-, F^-, NO_3^-N, SO_4^{2-}, HCO_3^- and PO_4^{3-} are less than 3 (β_2<3) showed a low peak relatively small number of scores fall in the center of the distribution Therefore the shape of the curve was platykurtic for all the above parameters (**Fig. 3)**. For pH kurtosis value is equal to three (β_2=3) which was not skewed in either direction therefore the shape of the curve was found normal (**Fig. 2).** For EC it was Mesokurtic Curve (β_2 >3) because a moderate peak representing a normal number of scores in the middle of the distribution (Fig. 1). Among the physico-chemical parameters Ca, Na and K were slight higher than the permissible limit. In all water samples iron was found higher than the permissible limit. The calculated TDS, SAR, RSC and SSP are presented in **Table 4**.

Table 2: Descriptive Statistical Analysis of pH, EC, Ca, Mg, Na, K and B

Sl No	Range	Min	Max	Mean	SD	Skewness	Kurtosis
pH	1.79	6.23	8.02	7.008667	0.340939	0.350505	2.458674=3
EC	0.3237	0.0892	0.4129	0.154.33	81.21457	1.996273	3.630062>3
Ca	143.27	13.56	156.83	64.399	40.72177	0.511251	-0.50978<3
Mg	47.64	2.19	49.83	19.101	13.66997	0.647758	-0.41396<3
Na	60.71	6.88	67.59	32.443	17.22439	0.24507	-0.91433<3
K	16.68	1.89	18.57	7.495333	4.734635	0.591311	-0.55622<3
B	0.39	0.02	0.41	0.131667	0.105277	0.976877	0.175283<3

Table 3: Descriptive Statistics of Fe, Cl^-, F^-, NO_3^-N, SO_4^{2-}, HCO_3^- and PO_4^{3-}

Sl No	Range	Min	Max	Mean	SD	Skewness	Kurtosis
Fe	5.03	1.12	6.15	3.597333	1.486066	0.133081	-0.8242<3
F-	20.55	1.09	21.64	7.488333	6.211129	1.120368	0.350618<3
Cl-	1.37	0.01	1.38	0.3295	0.437895	1.575341	0.989813<3
Nitrate	4.84	0.19	5.03	1.798667	1.477782	0.736504	-0.85853<3
Sulphate	11.03	28.98	40.01	31.568	3.06466	1.850663	2.314108<3
HCO_3-	77.8	78.98	156.7	106.731	16.58738	1.195802	1.760286<3
PO_4^{3-}	1.01	0.04	1.05	0.389667	0.313605	0.938551	-0.24972<3

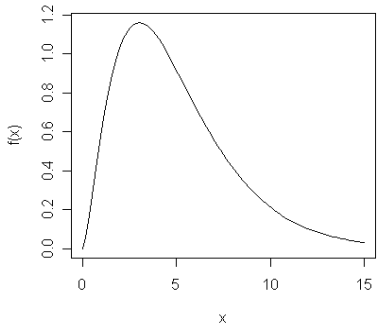

Fig. 1: Mesokurtik

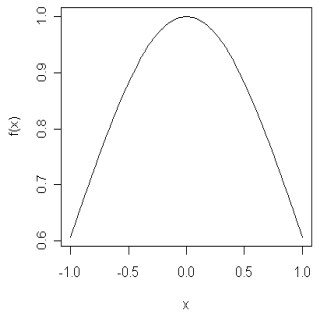

Fig. 2: Normal

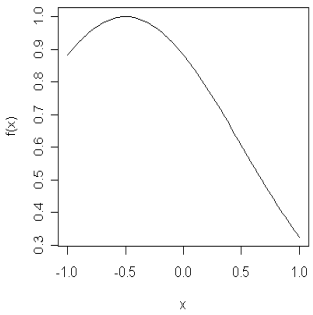

Fig. 3: Platykurtic

Table 4: Estimated values of TDS, SAR, SSP and RSC with classification

Sl.No	TDS	SAR		SSP%		RSC	
	mg/l	Value	Class	Value	Class	Value	Class
1	129.44	10.38	G	53.93	M	2.55	B
2	138.89	5.49	E	31.65	G	2.97	B
3	-	6.51	E	31.72	G	-3.18	S
4	-	2.93	E	13.01	E	-2.01	S
5	-	5.3	E	28.83	G	0.95	S
6	-	5.85	E	35.21	G	1.99	G
7	209.66	4.63	E	25.86	G	4.67	B
8	109.44	20.65	M	71.17	B	5.02	B
9	-	16.25	G	62.53	B	-7.66	S
10	-	11.9	G	51.67	M	-2.67	S
11	167.21	6.36	E	28.11	G	4.51	B
12	134.44	6.73	E	30.06	G	1.34	G
13	176.45	3.53	E	18.66	E	2.01	M

14	123.09	3.65	E	14.74	E	1.22	S
15	121.00	3.69	E	19.9	E	1.39	S
16	109.77	1.87	E	8.65	E	-.098	S
17	-	6.86	E	29.71	G	-.066	S
18	120.21	5.63	E	26.29	G	1.78	S
19	-	4.75	E	21.24	G	2.77	B
20	146.39	2.24	E	13.05	E	1.67	G
21	-	24.14	M	70.07	B	1.56	G
22	-	2.73	E	25.98	G	2.98	B
23	105.70	5.78	E	25.22	G	3.45	B
24	129.80	2.11	E	14.45	E	-4.56	S
25	138.12	1.02	E	6.91	E	-3.12	S
26	101.48	1.3	E	6.78	E	2.77	B
27	122.09	9.16	E	39.44	G	1.23	G
28	126.89	3.08	E	18.06	E	1.30	G
29	152.11	2.27	E	24.22	G	-.067	S
30	-	4.11	E	35.26	G	-.088	S

E: Excellent: G: Good; M: Medium: S: Suitable; B: Bad

The SAR value ranges from 1.02 to 24.14. Out of 30 sampling stations 26 station's SAR are found excellent for irrigation (SAR<10), two station falls in good class (SAR=10-18) and other two falls in medium class (**Fig. 4**). The RSC ranges from -4.56 to 5.02, its tolerance limit as per Indian Standard is 1.25. Waters with RSC greater than 2.5 are deleterious while less than 1.25 are considered to be safe. The study revealed that more than 50% water samples are not suitable for irrigation purposes (**Fig. 5**). The range of SSP% was recorded 6.78-70.07. SSP% for ten stations found in excellent category (SSP% <20), fifteen stations in good category (SSP%= 20-40) and others are medium to vary bad category (**Fig. 6**).

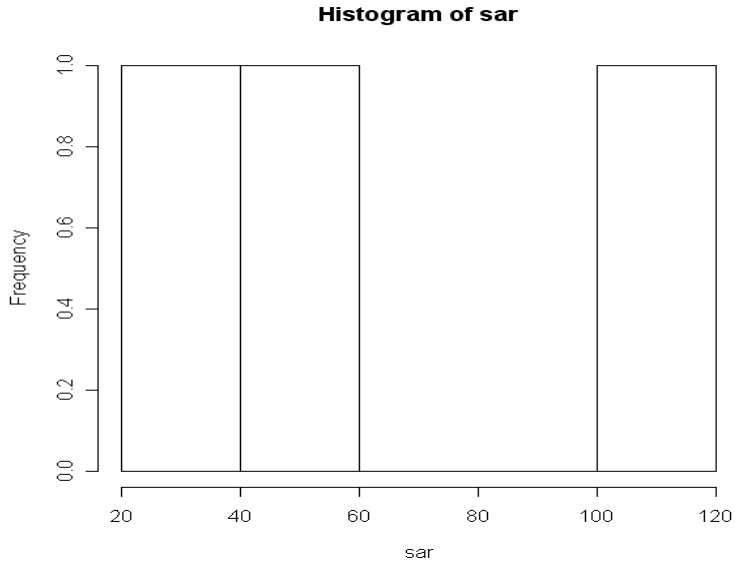

Fig. 4: Histogram of total frequency of SAR with respect to Excellent, Good and Medium

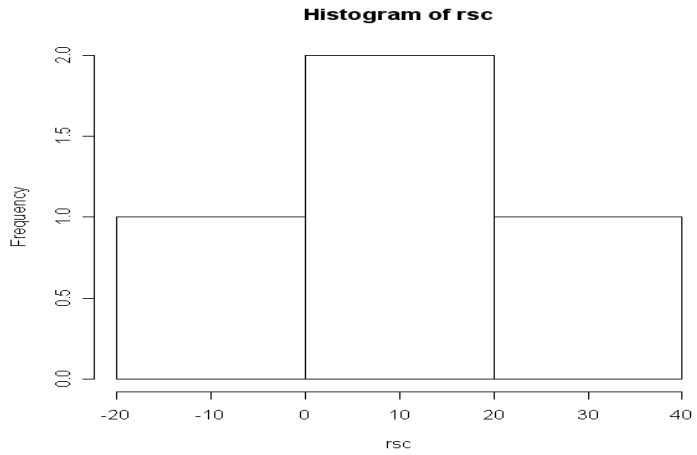

Fig. 5: Histogram of total frequency of RSC with respect to Good, Medium, Suitable and Bad

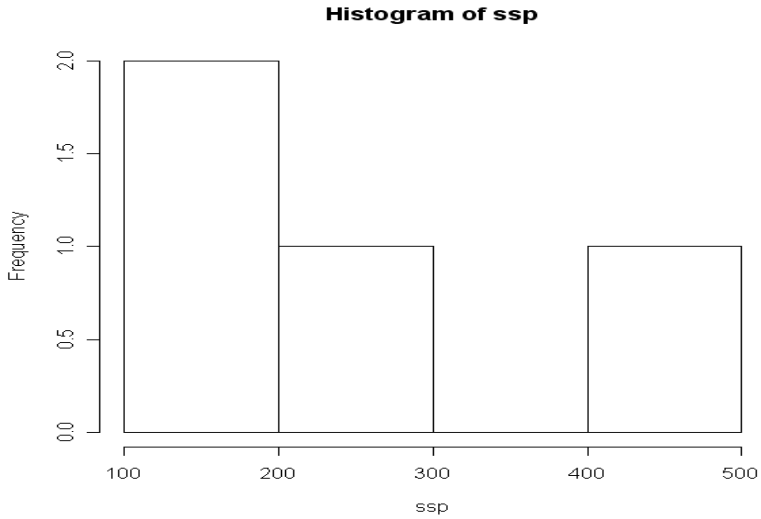

Fig. 6: Histogram of total frequency of SSP% with respect to Excellent, Good, Medium and Bad.

CONCLUSION

The objective of the work was to determine the water quality of underground sources in the tea garden areas of Golaghat district of Assam so as to assess the suitability of water for irrigation. The present investigation has led us to conclude that the quality of water samples subjected to study was acceptable for majority of physico-chemical parameters as it falls within maximum permissible limit of irrigation guidelines [Ayers and Westcot, 1976; Minakshi *et al*., 2006; Minakshi *et al*., 2004]. Though high yielding varieties and other modern inputs of farming are widely adopted, in respect of water use and water regulation the farmers in the study area still poorly informed and have not paid their attention. In order to sustain agriculture and to achieve maximum production irrigation water quality monitoring is very much important for a developing state like Assam.

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