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Study of ground water in a village of coastal West Bengal using geo-electrical method

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Abstract

The productivity of Coastal West Bengal is low. This is mainly due to high ground water salinity particularly in rabi season. In many areas ground water may occur in perched aquifer at greater depths (>40 m and up to 300 m) which is non saline and available for cultivation of crops. Geological information and bore hole statistics of an area help in assessing potential ground water of the area. Since ground water salinity changes in different seasons in the area, there is a need to assess ground water salinity in different seasons. The intrusion of saline ground water from nearby river in different locations of adjacent villages may also make the area saline. The sea water inundation during monsoon due to high rainfall or cyclone leaves salts in the soil and makes soil saline Therefore, it is necessary to study ground water potential and quality in different seasons in these villages. Resistivity Sounding (VES) assuming Schlumberger configuration were carried out in 12 locations in a sea water inundated village (Kanthalberia) of Coastal West Bengal. Ground water samples from nearby tube well (of VES points) were also collected . Four to five geo-electrical layers were found out in the area within a depth of 60 m below ground level. The inter relationship between longitudinal unit conductance (S) and EC of ground water samples showed that EC values increased linearly with S values. S values were positively correlated with EC2 of soil samples. The transverse unit resistance (T) was negatively correlated with EC2 of soil. Chemical analysis of ground water samples showed that the quality of water was good with low salinity and low alkali hazard and could be grouped as C2/3S1 of USDA irrigation water quality classification.

Keywords: *Ground water, coastal area, geo-electrical method*

Introduction

The productivity of agricultural produce of Coastal West Bengal is low. This is mainly due to high ground water salinity particularly in *spring* season. In many areas ground water may occur in perched aquifer at greater depths (>40 m and up to 300 m) which is non saline and available for cultivation of crops (Bandyopadhyay, 2011). Exploration of ground water sources by geo-electrical method is one of the inexpensive and in-situ methods and has been used for long (Keller and Frischnecht, 1966; Koefoed, 1979).

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Geological information and bore hole lithologs of an area help in assessing potential ground water of the area (Kumar *et al*., 2005). The intrusion of saline ground water from nearby river in different locations of adjacent villages (Kathalberia) may also make the area saline. The sea water inundation during monsoon due to high rainfall or cyclone leaves salts in the soil and makes soil saline (Alhumimidi, 2020). Therefore, it is necessary to study ground water potential and quality in different seasons in these villages. The ground water quality and potential at different depths can be assessed through resistivity soundings and geochemical data. Since ground water salinity changes in different seasons in the area, there is a need to assess ground water salinity in different seasons. The sea water inundation during monsoon due to high rainfall or cyclone leaves salts in the soil and makes soil saline. The electrical resistivity method in combination with hydrogeological data and tube well bore hole lithologs have been proved to be very successful for the assessment of ground water, its potential and quality at different depths (Chandrasekharan, 1988; Chandrasekharan and Singh, 1995).. Hence, an attempt is being made in this study to estimate ground water potential and quality at various depths.

Materials and methods

Physiography and drainage

The study area lies at Kanthalberia village of Canning 1 Block (South 24 Parganas district) of coastal West Bengal (Fig. 1). The study area (13.3 ha) is mostly under autumn rice. It is a plain area and its eastern part is having low elevation than western part (Fig. 1). The elevation is 3 m above mean sea level. It is an extensive alluvial tract and the general slope is towards east and south-east.

Hydrogeology

The major water bearing formation in the study area is quaternary & tertiary alluvium. Quaternary deltaic sediments composed of clay, silt and sand of various grades, gravels, pebbles etc., remain underlain by upper tertiary formations. Ground water is restricted to weathered residuum with medium yield (5-6 lps). The fine sand and clay layers form the potential aquifers which are regionally extensive and often interconnected. Adequate thickness of aquifers (12-60 m) is available for tapping in shallow and deep tube wells. Water table lies 0.5-6 m below the ground level. The pH of ground water is low (4.5) and the chlorine content is relatively high. Twelve vertical electrical soundings (VES) were carried out in the study area. Ground water samples from nearby villages were also collected for geochemical analysis.

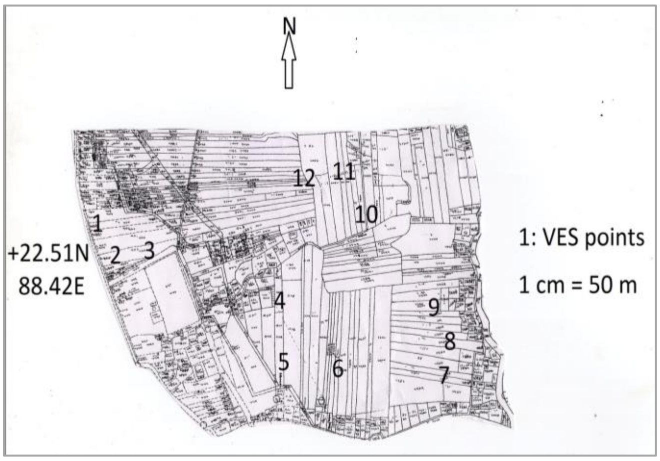


Fig.1

Fig.1. Study area (Kanthalberia village of coastal West Bengal; 1: VES Points)

Results and Discussion

Geo-electrical investigations

Field investigations were carried out in the kanthalberia village. Twelve VES were carried out throughout the village (Fig. 1) to determine the resistivities of different subsurface layers and correlate with the nearby borehole lithologs to understand the overall geohydrological situations. Out of these, VES 1, 2, 3 come in the western part and VES 4,5,6,7,8,9,10,11,12 come in the eastern part of the study area. A road passing north-south direction divides the VES points. The field data were interpreted for true resistivity and corresponding thickness of different sub-surface horizons. To locate the potential aquifer, the Dar Zarrouk parameters were used. Ground water samples were collected from tube wells situated near different VES locations and analyzed for EC, pH, Na, K, Ca, Mg, CO3, HCO3, Cl etc. The interpreted (true) resistivity values along with the thickness of different formations for VES points indicate five geoelectric layers (Table 1). The iso-resistivity contour map for different depth zones were drawn separately in Surfer 9 (Fig. 3). Resistivity data of VES 1 was correlated with nearby bore hole data.

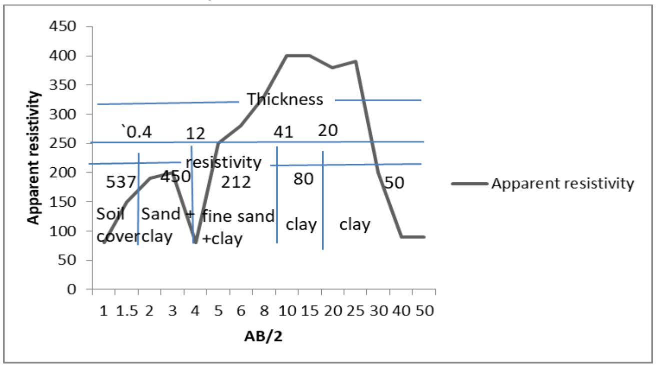


Fig.2

Fig.2. Correlation of nearby bore hole lithologs with resistivity data

Resistivity data of VES 1 was compared with the borehole lithology of adjoining tube wells. The comparison of VES 1 with borehole lithology is given below-

The true resistivity data of VES 1 show the presence of a layer of 537 ohm-m up to 0.4 m and another layer of 450 ohm-m at 12.0 m (Fig.2).

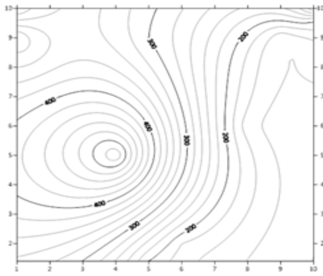


Fig. 3(1)

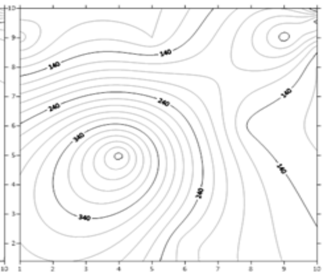
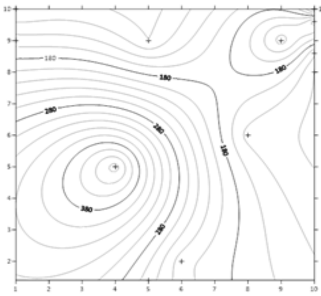


Fig. 3(2)



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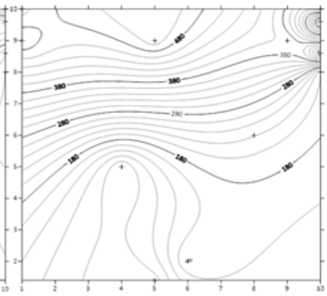

Fig. 3(4)

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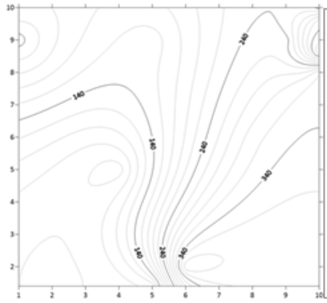

Fig. 3(5)

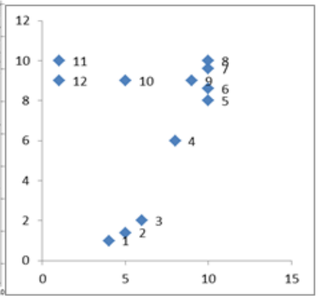

Fig. 3(6)

Fig. 3(6). Iso-resisitivity contours of geoelectric layers for depth range (m) below ground level (1) 0.4-15 (2) 4-30, (3) 10-41, (4) 10-68 and (5) up to 80 (1: VES points)

Table 1. Chemical characteristics of groundwater samples of kanthalberia village

Tube well location	EC (dS/m)	pH	Na^+	Cations and anions (me/l)						RSC (me/l)	SAR
				K^+	Ca^{+2}	Mg^{+2}	CO_3^{-2}	HCO_3^{-1}	Cl^{-1}		
1	1.4	5.4	1.9	0.24	8	4	2	12	13.5	2	0.77
2	1.67	5.6	0.5	0.16	10	7	3	15	9	1	0.79
3	1.06	5.7	2.3	0.51	5	7	4	10	27	2	0.94
4	1.06	5.4	0.9	0.15	5	5	2	10	4.5	2	0.43
5	0.93	5.0	1.1	0.18	5	4	2	10	4.5	3	0.51
6	0.76	5.3	0.9	0.15	5	4	3	7	5	1	0.45
7	0.55	5.0	4.2	0.38	6	4	4	7	27	1	1.90
8	1.68	4.1	2.5	0.21	6	6	5	8	18	1	1.02

Tube well location: 1. Near VES 1, 2. Near VES 3, 3. Near VES 4, 4. Near VES 5, 5. Near VES 6. 6. Near VES 7 7. Near VES 9, 8. Near VES 10

The resistivity values of 145-537 ohm-m up to 0.4-15 m indicate presence of soil cover (clay) and mangrove roots. The 450 ohm-m resistivity up to 12.0 m represents soil cover and sand. The 3rd layer with a resistivity of 212 ohm-m corresponds to fine sand and clay. In the interpreted data, the interface between 3rd and 4th layers is at 41.0 m below ground level (bgl) which agrees well with the borehole data. The resistivities of 3rd and 4th layer indicated water bearing zones. The resistivity of 80 and 50 ohm-m in the4th and 5th layer indicates presence of clay and small amount of kankar.

The first layer is upper ploughed layer and unsaturated soil. Predominantly clayey, high resistivity of 537 ohm-m at VES1 is due to the presence of hard plant root. Existence of a hard layer below the puddle rice soil, contains sand and clay with relatively higher resistivity values. This layer extends 0.4 to 15 m below ground level (bgl) (Fig. 3). The 2nd layer is ploughed layer and saturated soil. This layer extends from 4 m to 30 m bgl. Third layer is semi weathered zone of gneisses, contains clay and fine sand at higher depth up to 21-39 m and clay and hard sand (kankar) with relatively high resistivity (=300 ohm-m) at higher depth of 21-68 m. Occurrence of good quality of ground water is found throughout. Fourth layer extends from 10 m-68 m with a resistivity of 80 to 300 ohm- m indicating good quality ground water, low resistivity layer is also the aquifer with high amount of clay. The fifth layer is having a resistivity of 50-395 indicates the presence of clay and small amount of kankar. High resistivity at VES 3 & 4 indicated presence of kankar. Low resistivity of other VES points are due to presence of clay (Fig. 3).

Geochemical investigations of ground water

The electrical conductivity (EC) of ground water ranged from 0.55 to 1.68 dS m^{-1}, representing medium ($C_2/_3$) salinity group of USDA classification of irrigation water. The relatively high salinity (C_3) of irrigation water near some of the VES points was possibly due the presence of saline aquifer zone (Table 1). The pH of the water samples varies from 4.1-5.7 with majority of the samples having pH>5.0, which indicates that the ground water was acidic. Carbonates in the ground water samples were in trace amount in most of the tube wells (2-5 me l^{-1}). Bi-carbonate ions ranged from 7.0-15.0 me l^{-1}. The bi-carbonate content of the tube well water 6 and 7 were less than the other tube wells. High bicarbonate caused slight alkalinity in the ground water. The residual sodium carbonate (RSC) of the samples varied from 1.0 to 3.0 me l^{-1}. According to RSC irrigation water classification, samples 2,6,7, 8 could be safe, although RSC of other samples were slightly higher (samples 1, 3, 4 and 5), the harmful effects were not prominent because of low carbonate content. In clay loam to loam soil under Indian conditions, the samples 5 are also considered to be safe, although these are not suitable for use as per USDA classification. The sodium absorption ratio (SAR) of ground water samples varied from 0.51-1.9 me l^{-1}. On the basis of USDA classification, the samples may be classified under S_1 (low alkali hazards). The high chloride and sodium ion concentration in sample 1, 3, 7 & 8 (> 5 me l^{-1}) in the ground water samples were responsible for relatively high SAR values. On the whole, the ground water of the study area

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could be grouped under $C_2/_3S_1$. The interrelationship between the longitudinal unit conductance (S) and the EC of ground water samples collected from the tube wells adjoining to VES points showed that EC values of ground water increase linearly with the S values.

The correlation was studied between longitudinal unit conductance (S), transverse unit resistance (T) and EC values of surface soil. The correlation was found to be 0.20 for S and EC, where as it was -0.37 for T and EC (Raut *et al.*, 2011).

Conclusion

The study found that there were 4-5 geoelectric layer present in the area up to a depth of 80m. Correlation of bore whole data with apparent resistivity values gave the true resistivity values of different subsurface configurations. The ground water of the tube wells were mostly non saline and chloride content was high in one or two samples. Thus the ground water could be grouped as $C_{2/3}S_1$ of USDA irrigation water quality classification.

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