



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

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### Abstract

Vertical Electrical Sounding (VES) assuming Schlumberger configuration were carried out in 12 locations in a sea water inundated village (Kanthalberia) of Coastal West Bengal. Two vertical sections across the river Matla (VED 1'-4' and VED 5'-8') were also carried out. Ground water samples from nearby tube well (of VES points) were also collected. Five geo-electrical layers were found out in the area within a depth of 90 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 EC<sub>2</sub> of soil samples. The transverse unit resistance (T) was negatively correlated with EC<sub>2</sub> 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 C<sub>3</sub>S<sub>1</sub> of USDA irrigation water quality classification.

**Keywords:** VES, ground water, USDA

### Introduction

The crop 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) which is non saline and available for cultivation of crops (Bandyopadhyay, 2011). 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.

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). The sea water inundation during monsoon due to high rainfall or cyclone leaves salts in the soil and makes soil saline (Alhumimidi, 2020). 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 different 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 kharif 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.

Field investigations were carried out in the kanthalberia village. Twelve Vertical Electrical Sounding (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. Two vertical section along VES 5, 4, 12 (VES 1', 2', 3' & 4') and VES 7, 8, 9 (VES 5', 6', 7' & 8') were also carried out (Table 1). 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, CO<sub>3</sub>, HCO<sub>3</sub>, Cl etc. Ground water samples from nearby tube wells were also collected for geochemical analysis.

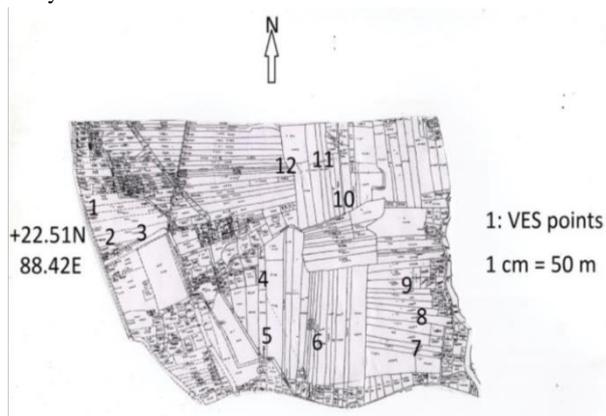


Fig. 1. Study area (Kathalberia village of coastal West Bengal).

**Results and discussions**

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). 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 the 4th and 5th layer indicates presence of clay and small amount of kankar.

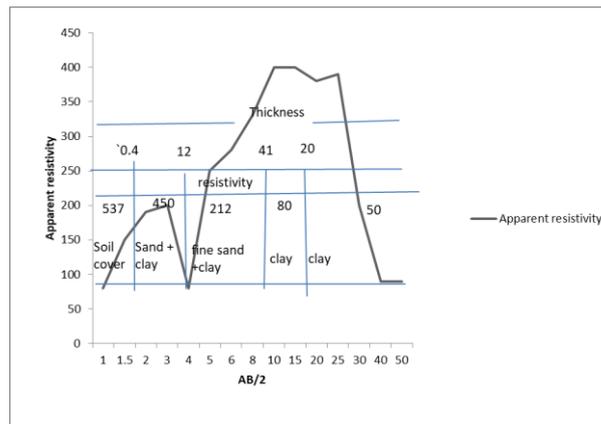


Fig. 2. Comparison of VES data with tube well bore hole lithology

Table 1. Interpreted resistivity values for different VES points

VES NO.	Layer no.				
	I	II	III	IV	V
1' h p	15 200	30 250	37.6 370	24 90	? 86
2' h p	1 177	6 81	27 201	20 166	? 200
3' h p	2 250	10 300	15 400	22.5 180	? 150
4' h p	1 300	5.7 450	20 190	15 150	? 250
5' h p	3 300	25 200	30 400	15 100	? 80
6' h p	2 350	10 180	20 300	25 150	? 200
7' h p	1.5 320	15 200	18 320	20 300	? 100
8' h p	1.5 310	15 200	25 320	15 180	? 170

h- thickness in m; p-resistivity in ohm-m

The interpreted (true) resistivity values along with the thickness of different formations for VES points indicate five

geoelectric layers (Table 2). The layer wise description of different subsurface configurations are given below-

**Table 2. Description of different geo-electric layers**

Geoelectric layer	Depth below ground level	Resistivity range in Ohm-m	Inference
1	1-15	177-350	Upper ploughed layer and unsaturated soil. Predominantly clayey, high resistivity of 300 ohm-m at VES 6' is due to the presence of hard plant root. Existence of a hard layer below the puddle rice soil,
2	5.7-30	180-450	It is lower ploughed layer and saturated soil
3	15-37.6	190-400	Semi weathered zone of gneisses, contains clay and fine sand at lower depth up to 15-38 m and clay and hard sand (kankar) with relatively high resistivity. Occurrence of good quality ground water (Raut et al., 2011)

4	15-25	100-320	Water potential zones. Relatively high resistivity at VES 2', 3', 7' & 8' indicates materials with less saline to good quality ground water.
5	Up to 90	170-320	Relatively low resistivities indicated presence of clay in most of the VES points. High resistivity at VES 4' indicated unsaturated zone

**Table 2. Physico-chemical parameters of soil collected from Kathalberia village**

Sites	Sand %	Silt %	Clay %	EC	pH	Organic C	Saturated moisture
1	53	20	27	0.60	5.9	1.60	0.60
2	54	19	27	0.24	6.4	1.70	0.59
3	53	10	37	0.50	6.2	2.20	0.58
4	57	20	27	1.05	6.7	1.10	0.58
5	34	19	47	0.86	6.4	0.50	0.68
6	37	19	44	0.67	6.0	1.30	0.69
7	34	29	37	0.84	5.7	0.86	0.61
8	43	10	47	0.50	5.7	0.20	0.65

Physico-chemical parameters were studied from the soils collected from Kathalberia village. Soil samples were collected during Feb. –March, 2025. Soils were collected from eight different sites coming near the VES locations and

analyzed for texture, EC, pH, organic carbon and saturated moisture content. Clay content in different sites of Kanthalberia village varied from 27-47% and was sandy clay loam to clay. Sand content for the same soils varied from 34-57% . In 0-20

cm depth. EC<sub>2</sub> values were low 0.24-1.05 dS/m. Organic carbon content varied from 0.20-2.2%. High organic carbon content (2.2%) may be due to the addition of organic matter on that site (Table 2).

**Table 3. Geochemical parameters of ground water collected from Kanthalberia village**

Tube well location	EC (dS/m)	pH	Cations and anions (me/l)							RSC (me/l)	SAR
			Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>+2</sup>	Mg <sup>+2</sup>	CO <sub>3</sub> <sup>-2</sup>	HCO <sub>3</sub> <sup>-1</sup>	Cl <sup>-1</sup>		
1	1.10	8.0	0.60	0.10	7	7	2	13.0	8.0	1.0	0.23
2	1.13	7.8	0.17	0.12	6	7	1	14.0	15	2.0	0.10
3	1.46	7.7	0.17	0.13	9	3	1	13.5	15	2.5	0.10
4	1.17	7.8	0.3	0.10	4	6	3	10.0	14	3.0	0.13
5	1.72	7.1	0.65	0.35	6	7	2	14.0	4.0	3.0	0.26
6	1.08	8.7	0.17	0.13	6	4	1.5	11.0	9.0	2.5	0.45
7	1.16	8.8	0.17	0.10	4	4	2.0	9.0	8.0	3.0	0.10
8	2.25	7.5	0.43	0.15	5	5	1.0	12.0	10	3.0	0.20

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

*Geochemical investigations of ground water*

The electrical conductivity (EC) of ground water ranged from 1.08 to 2.25 dS m<sup>-1</sup>, representing medium (C<sub>3</sub>) salinity group of USDA classification of irrigation water. The relatively high salinity (C<sub>3</sub>) of irrigation water near one of the VES points was possibly due the presence of saline aquifer zone (Table 3). The pH of the water samples varies from 7.1-8.8 with majority of the samples having pH>7.0, which indicates that the ground water was alkaline. Carbonates in the ground water samples were in trace amount in most of the tube wells (1.0-2.0 me l<sup>-1</sup>). Bi-carbonate ions ranged from 9.0-14.0 me l<sup>-1</sup>. 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<sup>-1</sup>. According to RSC irrigation water classification, samples 1,2,3,6 could be safe, although RSC of other samples were slightly higher (4, 5, 7, 8), the harmful effects were not prominent because of low carbonate content. In clay loam to loam soil under Indian conditions, the samples 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 0.10-45 me l<sup>-1</sup>. On the basis of USDA classification, the samples may be classified under S<sub>1</sub> (low alkali hazards). The high chloride concentration in sample 2, 3, 4 & 8 (> 5 me l<sup>-1</sup>) in the ground water samples were responsible for relatively high SAR values. On the whole, the ground water of the study area could be grouped as C<sub>2</sub>/3S<sub>1</sub> of USDA irrigation water quality classification.

**Table 4. Correlation matrix for geochemical parameter, soil texture and EC**

Variables	S (30 m)	T (30 m)
Sand (0-0.15m)	-0.30	0.20
Silt (0-0.15m)	-0.26	0.25
Clay (0-0.15m)	0.24	-0.32
E.C. (1:2)	0.27	-0.21

The longitudinal conductance value (S) was positively correlated with EC of soil (r= 0.27) and clay (0.24). The S value was negatively correlated with sand and silt content (r values are -0.30 and -0.26, respectively). The transverse unit resistance (T) showed reverse trend (table 4).

**Conclusions**

The study found that there were five geoelectric layer present in the area up to a depth of 90 m (from two VES sections). 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 four samples. Both resistivity and geochemical data showed that change in resistivity values at different layers were due to

subsurface configuration, and may not be due to sea water intrusion. Thus the ground water could be grouped as  $C_2/3S_1$  of USDA irrigation water quality classification.

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