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Geo-electrical mapping and groundwater potential zoning in some selected pockets of Baromura hill of Tripura (India)

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Abstract: Baromura hill of Tripura is characterised by complex geology and very rugged landform. Water scarcity is a very general problem for the remote hilly villages of this area. Thus groundwater is considered as one of the most valuable natural resources in hilly villages of Baromura hill. The present study aims to prepare small area survey based geo-electrical mapping for understanding groundwater condition in some selected pockets of the study area. For that purpose one hill slope and one trough shaped low land (locally known as lunga) was selected. Soil resistivity meter was used for electrical survey. A circle plot was prepared for geo-electrical survey on the basis of which geo-electrical maps were drawn. In the studied hill slope morphology four sectors of ground water conditions were observed according to their electrical resistivity character namely shallowest zone, medium zone, deep zone and very deep zone. The trough shaped low land (lunga) is characterised by comparatively shallower condition of groundwater and it was divided into five classes namely near surface water, very shallow zone, shallow zone, medium shallow zone and medium zone. Though the depth of the water bearing strata cannot be detected by this method it is very suitable for understanding the groundwater potential zones in remote places like present study area.

Keywords: Groundwater, Geo-electrical mapping, Baromura hill, 2-pin survey, Hill slope, Low land

INTRODUCTION

Groundwater exploration in different physical environmental conditions is one of the most challenging issues in Applied Geophysics and Geotechnical Engineering from methodological stand point due to its application value. From environmental point of view groundwater is considered as an important physical component of the nature since it widely influences soil conditions, vegetation distribution, sustainable irrigation, archaeological sites etc (Gaber *et al.*, 1999; Mesbah, 2003; Mohamaden, 2005). In geophysical researches measuring electrical resistivity of soil is a popular technique for groundwater exploration which has been established by many early workers like Barker (1980), Bernard and Valla, (1991), Nowroozi *et al.* (1999), Ibrahim *et al.* (2004) and Nigm *et al.* (2008) . Many investigations like McNeill (1980) Palacky (1987) Dahlin (1993), Alfano (1993), Dahlin (1996), Christensen and Sørensen (1996), Dahlin and Loke (1997), Yoshida *et al.* (1997) George *et al.* (2008) and Akpan *et al.* (2009) strongly support the efficiency of electrical resistivity technique for understanding the physical characters of various soils/ rocks. Considering the importance of electrical survey in groundwater exploration the present authors decided to experiment on small area geo-electrical mapping for measuring groundwater conditions in some selected pockets of Baromura hill of Tripura. The main objective of this study is to find out an alternative and simple methodology which can be applied in such areas where lack of place, rugged landform and dense cover of vegetation together create problem for multi-electrode geo-electrical survey.

MATERIALS AND METHODS

General geomorphology and geology of the study area: Geologically Baromura hill is an elongated fold belt with complex structural setting (Dey *et al.,* 2009; Dey *et al.,* 2010) (Fig.1). This area is characterized by undulating / rugged landform which stretches north to south in Tripura. The crest of the anticlines forms the crest of the range and the gentle deep of the flanks form the slopes of the range. The highest elevation of Baromura is observed 197 m at 23.970416ºN latitude and 91.520739ºE longitude. In the south the elevation decreases gradually. The geological successions and their characters of the study area are shown in Table 1.

Selection of survey places: Initially two different micro-regional level environmental domains were selected for survey which are characterised by very uneven surface and of-course suffering by water scarcity. Geomorphologically the first selected area is a hill slope and the second one is a trough shaped low land within the hills (Plate.1). In both the places 30m X 30m areas

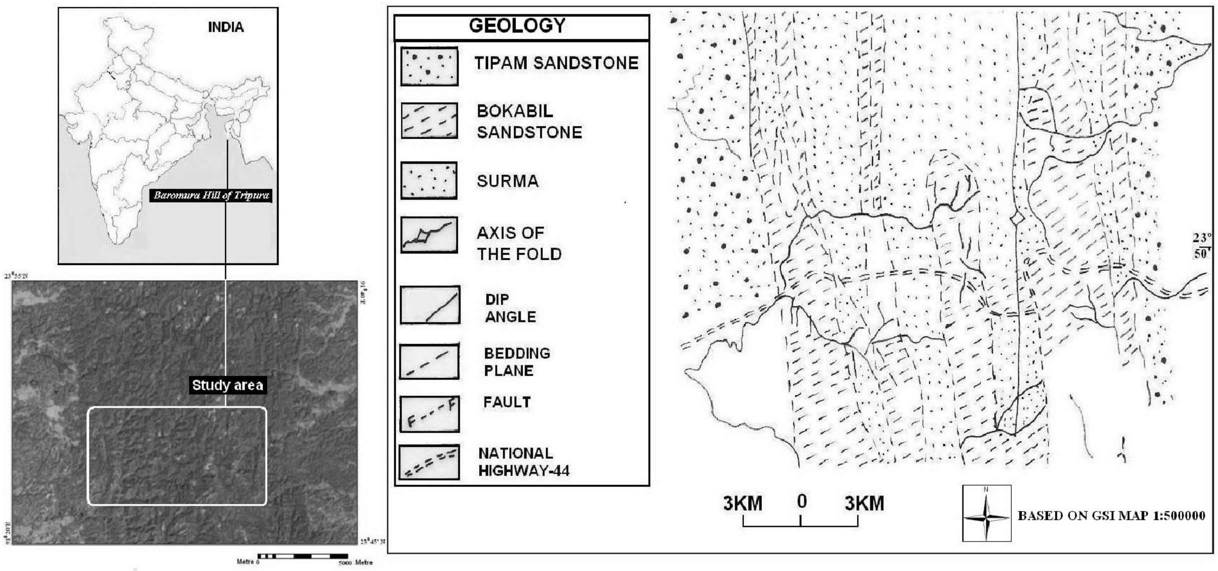

Fig.1. *Location, environs and geology of the study area.*

were taken for survey. The basic features of the selected places are as follows:

a) Hill slope: Most of the areas of Baromura Hill are marked by high angle hill slopes which are characterised by dense vegetation cover. Earlier these hill slopes were used for shifting cultivations by the local tribal people. Now rubber plantation has been introduced by the government in many hill slopes. The selected survey place for the present study is a high angle hill slope and located along National Highway 44. The soil of this area is very immature with low organic matter. This hill slope is covered with medium to dense vegetation.

b) Trough shaped low land: These types of lands are commonly found in the hills of Tripura which are locally known as "*lungas*". These are surrounded by high to medium angle slopes and covered by grasses and bushes. In narrow and elongated low lands rice and vegetable cultivation is done by the villagers. For the present research a deep and trough shaped *lunga* or lowland was selected from a remote place which is located 1.5 km north to National Highway 44.

Data generation and data analysis: Soil resistivity meter was used for assessing electrical data generation. Since the selected areas are very small and due to uneven surface condition and vegetation cover application of multi-electrodes is not possible in the present study 2-pin method was used for understanding the ground water conditions. For the purpose of the geo-electrical survey two basic conditions was maintained strictly

I. The survey was conducted in a sunny dry day during winter season when the sky was comparatively cloud free and level of moisture in atmosphere was very low.

II. The date of survey was fixed by observing that there was no rain fall for last 30 days, because rainfall influences to change the normal ground water condition.

Instead of random selection of points for data generation, which is very common method in 2-pin survey, a circle plot was prepared where reference electrode was fixed in the centre of the circle (Fig.2). Electrode P3 was used as reference point. Electrode P2 was used for electrical measurement on the selected points according to circle plot. For fixing ground control points on the reference electrodes GPS tool was used. The instrument reading was processed in the laboratory (Table.2 and Fig.3).

RESULTS

Data classification and groundwater zoning: Recorded data were placed on the circle plots for understanding physical natures of the selected 30m X 30m survey places

Table 1. Geological successions of Baromura hill.

Geological period	Epoch	Group	Formation	Lithology
Tertiary	Early Pliocene (5.3 million years)	Tipam	----------------	Marine-coastal and estuarine sand rocks with shale and fossil wood.
		LINE OF UNCONFORMITY		
	Miocene (23.3 million years)	Surma	Bokabil	Marine-coastal Shale with minor sandstone
		Base not seen		

(Source: Extracted from a unpublished report of Geological Survey of India, 2002).

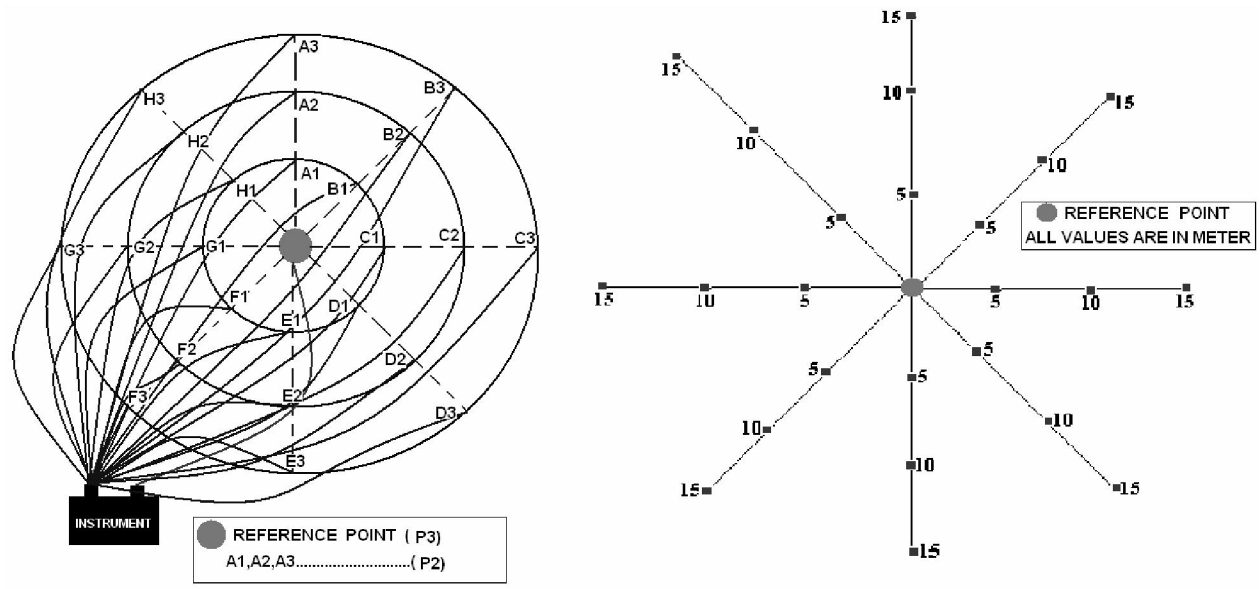

Fig.2. *Survey plot for geo-electrical mapping within 30mX30m areas.*

and isopleth mapping was done on the plots. On the basis of the calculated R value 4 classes of groundwater conditions were prepared for hill slope morphology namely shallowest zone or SZ (R=<550 Ω), medium zone or MZ (R=550 Ω to 579 Ω), deep zone or DZ (R=.580 to 610 Ω) and very deep zone or VDZ (R=> 610 Ω). From the obtained data it has been sheen that the second survey place is characterised by comparatively shallower condition of groundwater. In case of low land or lunga 5 classes were prepared namely near surface water or NSW

Table 2. Field data processing for classification of groundwater zones.

Stations of P2 on circles 1,2 and 3	Distance from reference electrode	Hill slope morphology		Low land or *Lunga*	
		Instrument reading	'R' Obtained (in Ω)	Instrument reading	'R' Obtained (in Ω)
A1	5 Metre	0.648	648 Ω	0.220	220 Ω
B1		0.609	609 Ω	0.384	384 Ω
C1		0.645	645 Ω	0.402	402 Ω
D1		0.590	590 Ω	0.403	403 Ω
E1		0.574	574 Ω	0.358	358 Ω
F1		0.537	537 Ω	0.379	379 Ω
G1		0.600	600 Ω	0.375	375 Ω
H1		0.652	652 Ω	0.374	374 Ω
A2	10 Metre	0.589	589 Ω	0.239	239 Ω
B2		0.493	493 Ω	0.360	360 Ω
C2		0.646	646 Ω	0.300	300 Ω
D2		0.552	552 Ω	0.374	374 Ω
E2		0.534	534 Ω	0.377	377 Ω
F2		0.544	544 Ω	0.386	386 Ω
G2		0.634	634 Ω	0.394	394 Ω
H2		0.606	606 Ω	0.372	372 Ω
A3	15 Metre	0.584	584 Ω	0.250	250 Ω
B3		0.534	534 Ω	0.344	344 Ω
C3		0.580	580 Ω	0.374	374 Ω
D3		0.531	531 Ω	0.381	381 Ω
E3		0.554	554 Ω	0.397	397 Ω
F3		0.539	539 Ω	0.396	396 Ω
G3		0.669	669 Ω	0.398	398 Ω
H3		0.624	624 Ω	0.387	387 Ω

R=Instrument reading X Range of the instrument Range of the instrument X10^3 Voltage-50V

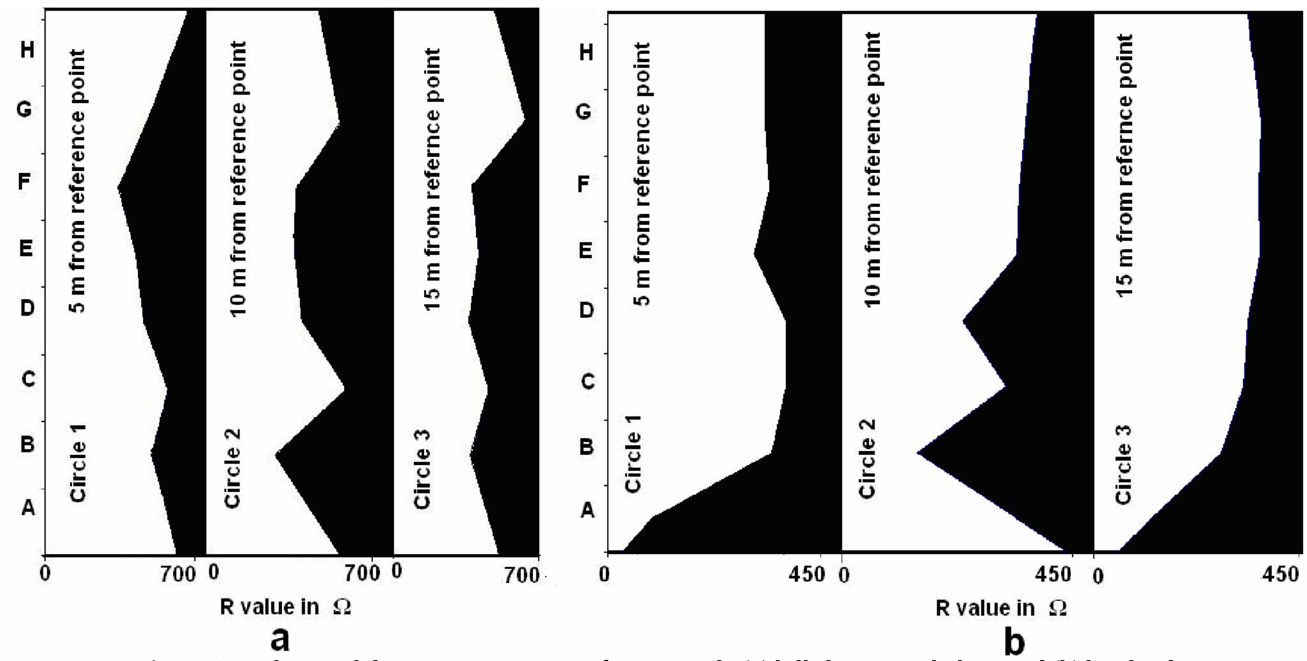

Fig. 3. *Geo-electrical data on A to H points of every circle (a) hill slope morphology and (b) low land.*

(R=<330 Ω), very shallow zone or VSZ (R=0. 330 Ω to 349 Ω), shallow zone or SZ (R=350 Ω to 369 Ω), medium shallow zone or MSZ (R= 370 Ω to 390 Ù) and medium zone or MZ (R=>390 Ω).

Geo-electrical nature of hill slope morphology: Maximum deep water level (VDZ) was found at the eastern, south-eastern and middle parts of this survey place where R value measured > 610 Ω. Slope angle of this part is very high and covered by grass to medium vegetation cover. Near the VDZ, in some pockets, R value varies between 550 Ω to 610 Ω which indicates the comparatively decrease of depth of water bearing strata from the surface. At many parts of southern, south-west, north-west to north eastern side of the survey place this range has been found which fall MZ and VZ classes. An evidence of medium deep condition of the water bearing strata (MZ) has been found at south, south-west, and pockets of north-west, north and north east sides where R value recorded between 550 Ω to 579 Ω. The shallowest ground water zone (SZ) has been detected in two parts namely south-west and northern-eastern and R value measured bellow 550 Ω (Fig.4a). In the northern part the minimum R value recorded 493Ω which can be considered as the best place for ground water exploration. This is comparatively lower slope and elevation is also comparatively low.

Trough shaped low land (lunga): From the instrument data it has been seen that the water bearing strata is comparatively close to the surface than the hill slope (Fig.4b). Higher R value recorded (>390 Ω) at northern and eastern parts (MZ) which indicates the deepest ground water condition in those places. At some points of north-west and middle parts R value measured between 370Ω to 390Ω (MSZ). Some portions of west, south-east and middle of this place are characterised by R value range between 350 Ω to 369 Ω (SZ). It has been observed that with the decrease of R value the amount of grass on the surface is increased and they become greener in colour. It indicates the shallow condition of water bearing strata.

Towards south there is a small wet land and ground water condition become very shallow (NSW). The R value varies from 330 Ω to 350 Ω at middle and southern parts. The lowest ground water condition is detected 220Ω at the middle part of this area which can be considered as the best place for tube well from financial point of view. From this place easily ground water can be extracted by minimum drilling.

DISCUSSION

In many recent experimental works vertical electrical sounding, multi-electrode methods and electromagnetic very low frequency profiling have been successfully applied for wide area groundwater exploration which reflects in the researches of Owen *et al.* (2005), Hamzah *et al.* (2007) and Ariyo *et al.* (2009). Geomorphologically the present study area Baromura hill of Tripura is characterised by very rugged landform and that causes groundwater exploration very difficult as a suitable flat land is rarely available in this place for geo-electrical survey. Geological complexity is another problem for groundwater exploration in this fold area though water scarcity is a very general problem to the local people and groundwater is considered as a valuable natural resource. Hence 2-pin method is the most suitable for understanding the physical nature of the soil and

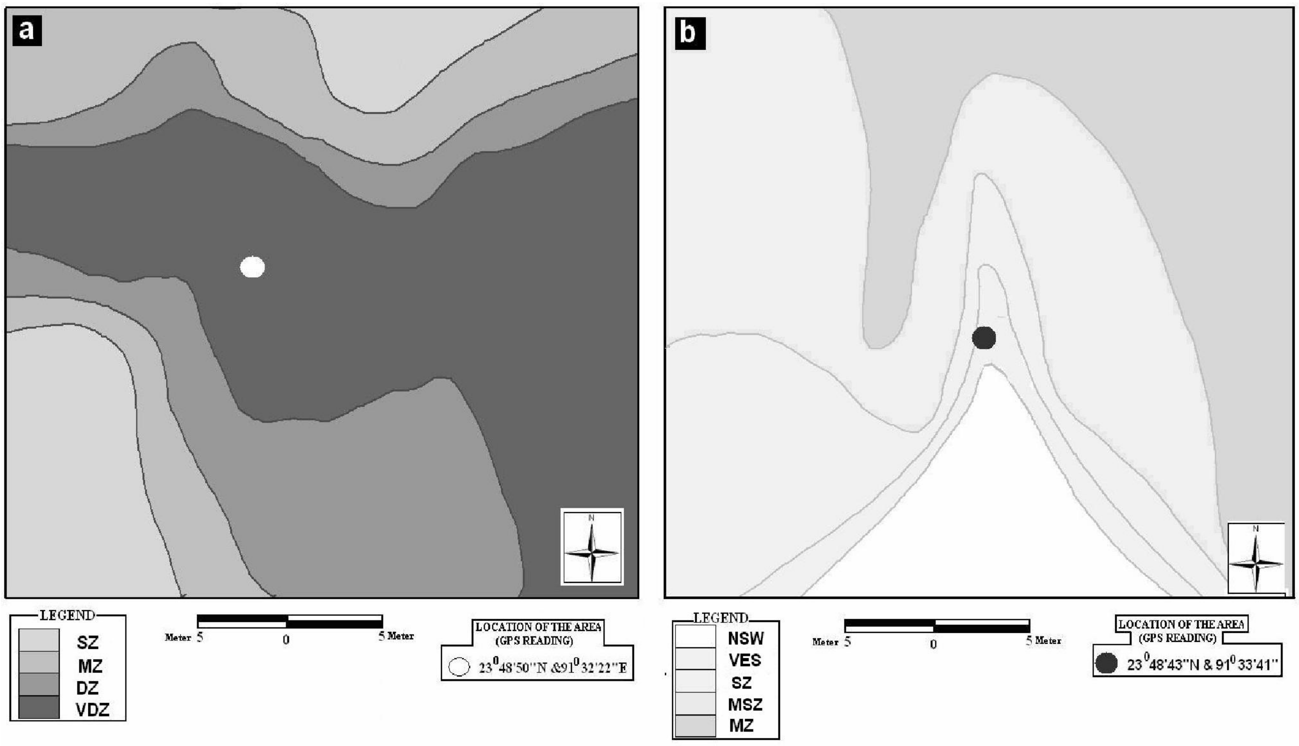

Fig.4. *Geo-electrical mapping for assessing ground water condition in (a) hill slope and (b) low land (lunga).*

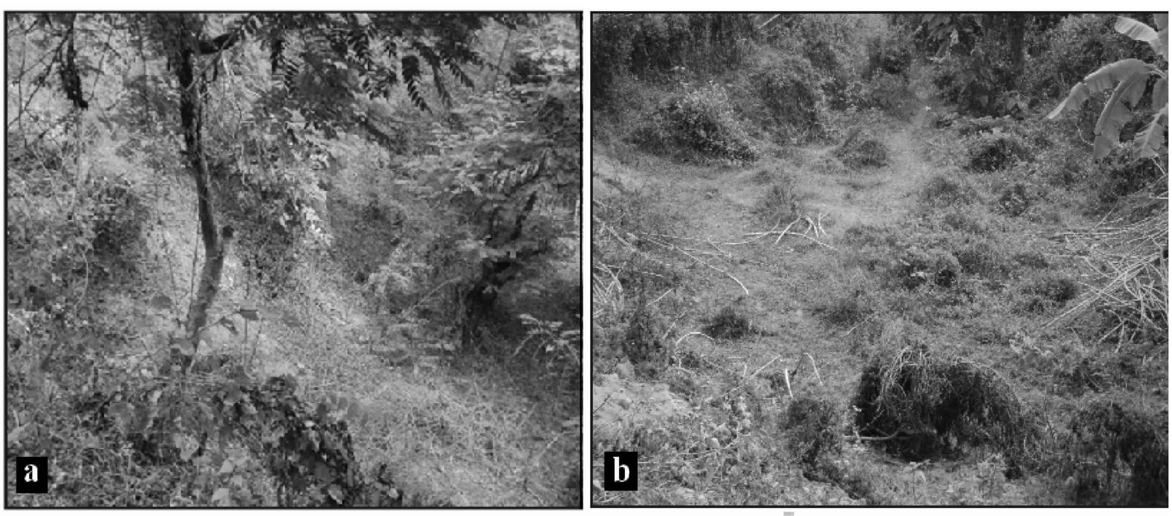

Plate.1. *Morphology of (a) hill slope and (b) low land (lunga).*

groundwater condition. During the study both merits and demerits of the applied method was observed. It is a simple method and not time-consuming at all. Circle plot can be prepared even in a very uneven land where many types of obstructions create problem for maximum number of data generation if random selection of survey points are done. Besides that the demerits of this method are also opened during the research. The main demerit of this method is that this method only can give an idea about the groundwater distribution without measuring the depth of water bearing strata. However this method can be very helpful for assessing the groundwater condition in the remote areas for construction of wells or for locating a perfect place for tube well.

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