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COSTAL ZONE MANAGEMENT

GEOELECTRICAL STUDIES IN ASCERTAINING FRESH-WATER ZONES IN COASTAL GOA

A. G. Chachadi and C. Joaquim S. John
Department of Geology, Goa University, Goa - 403 206

Abstract

The geoelectrical profiling provides a logical data for interpretation of the sea water front in the subsurface in the coastal belts. The use of this geoelectrical technique has been demonstrated for locating the fresh groundwater pockets very close the high tide zone in the Goa coast. These fresh water pockets are very useful to meet the local peoples drinking water demands especially during summer seasons when the public water supply taps run dry. Vertical Electrical sounding survey indicated that saline water encountered at a depth range of 15 m to 32m below the ground where resistivity is as low as 2 Ohm /m.

Introduction

Coasts have long been a major focus of human attention. Incidentally, one-third of the world's population is concentrated within 100km stretch of the coastline including the largest cities of the world. The changes induced by anthropogenic factors, whether purposeful or incidental, often achieve a magnitude or direction that is neither desired nor foreseen. Industrial as well as large urban complexes occupy much of the coastal margin of developing and developed countries. Water resources in this coastal areas therefore assume a special significance since any developmental activity will largely depend upon availability of fresh water to meet domestic, industrial and agricultural requirements.

Objectives

Looking into the drinking water problems of the coastal Goa it is thought fit to takeup the detailed water resources studies in the severely affected tracts of the north Goa coast. Under this multidisceplanary approaches have been adopted for gathering the necessary field data to arrive at the meaningful results. In the following paragraphs the studies related to the geoelectrical surveys have been described. The geoelectrical surveys were carriedout as one component of the entire study. The use of the geoelectrical surveys in deciphering the fresh water lenses very close to the high tide lines has been demonstrated.

Location and extent

The state of Goa possess more than 100km of coastline and about 250km long navigable inland waterways. Some of the best beaches of the country are located along this coastline, making it most attractive tourist destination in India. In recent years, there has been a phenomenal growth in the settlement areas and tourist related activities along the coastal belt. During peak summer and tourist seasons the shortage of water is severely felt all along the coastal belts. Invariably the settlers have dug shallow open wells to meet their daily demands. The real estate developers and the hotel and other industrial users have resorted to shallow and deep bore wells to draw ground water for use. Besides this the changing land use pattern has reduced the natural infiltration of rainfall into the ground. The combined effects of increased groundwater drawals and decreased rainwater infiltration has led to a complex pattern of sea water intrusions in the coastal belts of Goa.

Study Area and Topography:

The study area is a part of Bardez Taluka of North Goa District located between Fort Aguada in the south and Fort Chapora in the North. The area is represented on survey of India toposheets number. 48 E/10, 48 E/14, and 48 E/15 of 1:50,000 scale. The stretch is about 15km long in the north-south direction. About 2km wide active coastal belt accounting about 30 km2 area has been included in the present study. The area is bound by rivers Chapora and Mandovi in north and south directions respectively, besides Arabian Sea in the west (Fig.2). Many rocky promotories such as Aguada, Baga, Anjuna, Vagator and Chapora are seen protruding in between the sandy beaches. The land elevation in the plain varies from 0 to 20m above msl while it is about 60 to 75m on the intervening hills and promotories. The area is well developed and accessible through all weather metal roads and has very good network of communications from within and neighboring places. The main occupation of the people in this area is concerned with tourism related activities, apart from fishing and agriculture. The

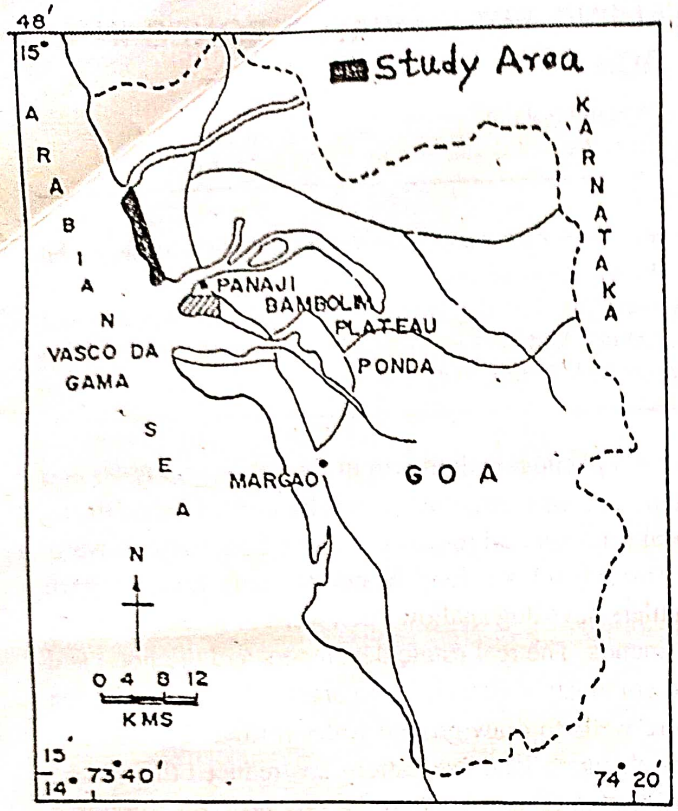


Fig.1 Location map of Study area

community setup of this area is typically of mixed type, where in both the urban and rural communities live side by side. The famous beaches of Sinquerim, Candolim, Calangute, Baga, Anjuna and Vagator are all located along this stretch. The well known holiday resorts such as Taj group of hotels, Sterling resorts are also located on this track.

Climate

The general climate of the area is mainly tropical and is influenced to a large extent by the conditions in the Arabian Sea. There are four seasons, viz. winter (December to February), summer or pre-monsoon (March to May), monsoon (June to September), and post monsoon (October to November). The climate is characterised by high humidity and less extremes of temperature. The temperature varies between 20°C to 33°C. The annual rainfall varies from 2700mm to 3500mm and the approximate number of rainy days are 110. The bulk of the rainfall is received during the SW monsoon (June to October). The average relative humidity is between 70 to 90%. The monthwise rainfall data for last 10 years for north and south Goa is presented in Fig. 2 (a&b). It can be seen from the figures that the maximum rainfall is recorded during the month of July. The predominant wind direction for summer, post-monsoon and winter seasons are reported to be SW-SE-N, S-SW, and E-NW-W, respectively.

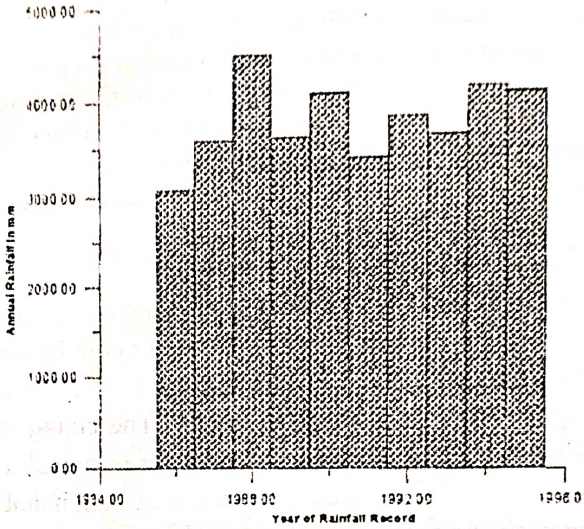


Fig. 1 (a): Annual Rainfall for North Goa from 1986 to 1995

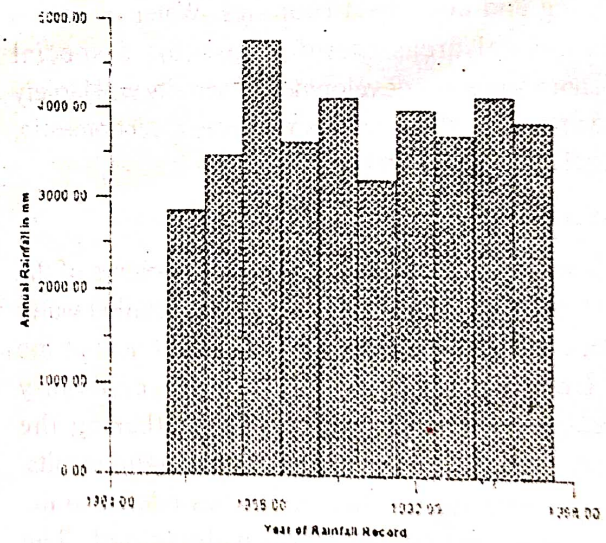


Fig. 1 (b): Annual Rainfall for South Goa from 1986 to 1995

Geology and Hydrogeology of the Area:

The rocks in the study area consist of metamorphic rocks of Precambrian age which are capped by ferruginous duricrust made of laterite and lateritic soils. The simplified sequence of rocks is

Recent - consisting beach sands, windblown sands, alluvial sands and clay

Subrecent - mainly hard laterites and lateritic, phyllitic, and manganiferous clays

Precambrian - includes metagraywacks, acid and basic intrusives

The metagraywacks is prone to lateritisation with the result that there are few outcrops in the area except at Aguada Fort, Baga head land, Vagator and below Chapora Fort in the form of wave cut platforms, terraces, sea stacks etc. The insitu lateritic rocks are exposed at rock promotories as cappings, the detrital laterites are seen exposed along the slopes of the plateaus and valley portions. Three different stages of development of laterities at different levels of planations are seen. The top portion of hills and plateaus are seen capped by hard massive laterites, that passes down into a mottled and pallid zone of lithomarge, consisting of ferrugenous and aluminous portions with the former overlying the latter. This often passes down abruptly into the massive unweathered parent rock underneath (Fig. 3 a and b).

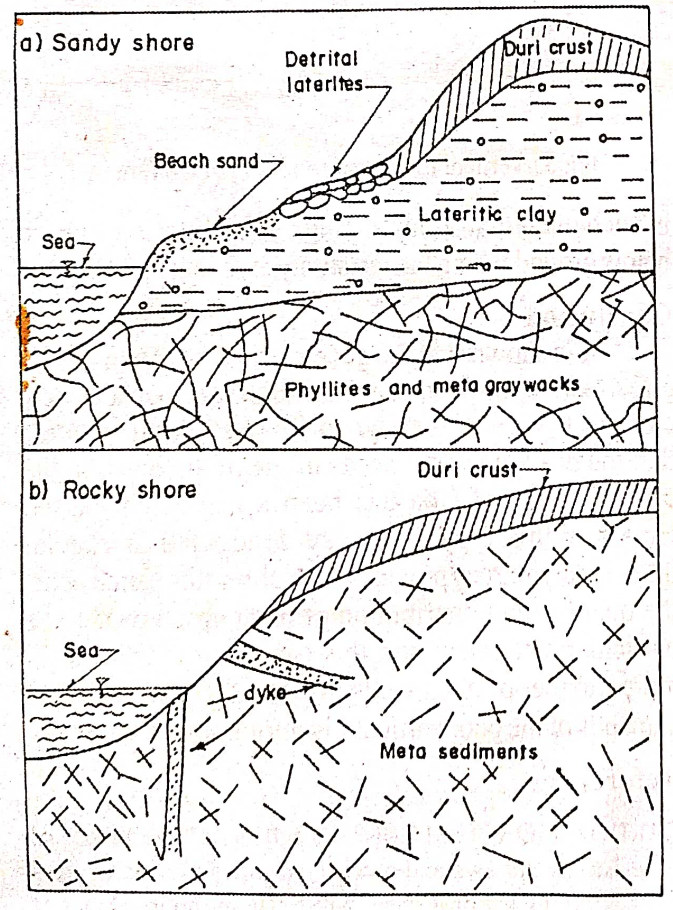


Fig. 3 Schematic sections across Goa coast

Beach sands, alluvial sands and wind blown sands occupy the lowest topographic elevations of the coastal tract. As observed in well sections the thickness of sands extends upto 12m metres below ground.

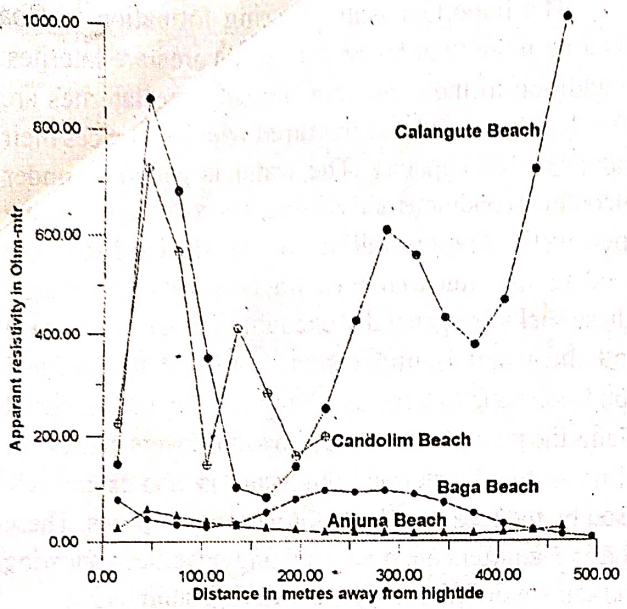
The important water bearing formation in Goa covering more than 60 percent of its area are laterites. In addition to their inherent porosity, the laterites are often highly jointed and fractured which enhances their water bearing capacity. The water is generally under unconfined conditions and is being tapped through shallow open wells. The crystalline rock at depths form very good aquifers due to intense fracturing at many places. These rocks are generally encountered below sea level and the water is under semi confined to confined conditions due to large overlying clay layers. In coastal plains the groundwater occurs in sandy layers in the form of unconfined water and this water is also extensively used by the local residents for various purposes. These shallow aquifers are over used and have been showing the salt water influx especially during summers.

All the ground water in the area is recharged through rainfall. In the recent years large scale urbanisation along this coast has been taking place. This urbanisation has inhibited the rain water recharge into the ground which is further accelerating the influx of the salt water inland due to decreased fresh ground water flow towards the sea.

Geo-Electrical Profiling

Among all the geophysical methods of exploration, geoelectrical methods provide most economical and reliable technique for groundwater exploration. The geoelectrical technique employ stimulating the ground with active current source and recording the resulting responses in terms of apparent ground resistivities. These apparent ground resistivities are then converted into true formation resistivities at specific depths using variety of interpretation techniques. The resulting true resistivity at a specific depth represent the average resistivities of all layers above that depth and hence they are not absolute values. However, these relative resistivities would provide important information for ascertaining lateral variations in the fluid properties besides lithological variations.

In the present study the electrical profiles at four sites across the beaches have been carried out at the constant electrode spacing of 10m. The values of apparent resistivities are plotted (Fig.4) versus distances away from the coast. These plots are called as electrical profiles. From these profiles it can be observed that the



Geoelectrical Profiles across Goan Shore (a=10m)

fluid properties vary as one moves from coast to the inland. Assuming the uniform lateral ground properties at 10m depth the variations in the apparent resistivity values can only be due to change in the fluid conductivity. The profiles taken at Calangute, Candolim, and Anjuna beaches show a sudden increase in the fluid resistance between coast and the 100m stretch inland. The increased fluid resistance can be interpreted as due to freshwater lens in this 100m belt parallel to the coast. For Baga beach profile the increase in fluid resistance is seen between 200m and 350m range inland. In general the resistivity highs indicate fresh water pockets and lows indicate salt water zones. The alternating nature of these profiles is due to the ingress of the salt water through the inland drains due to tidal influences.

Therefore the geoelectrical profiling can be effectively used to locate and monitor the freshwater pockets near to the coast. These fresh water pockets are serving as an important source of drinking water in the coastal areas of Goa particularly during the summer seasons. The findings can be confirmed from the fact that open wells are used very close to the high tide line to draw groundwater for drinking and construction purposes even during peak summer.

During the coarse of study several vertical electrical sounding (VES) surveys were also carriedout to find the depth distribution of the fluid resistivities and layer parameters. In figure 5 one of the VES curve alongwith the computed layer parameters and resistivities is shown. From the figure it is seen that the saline water

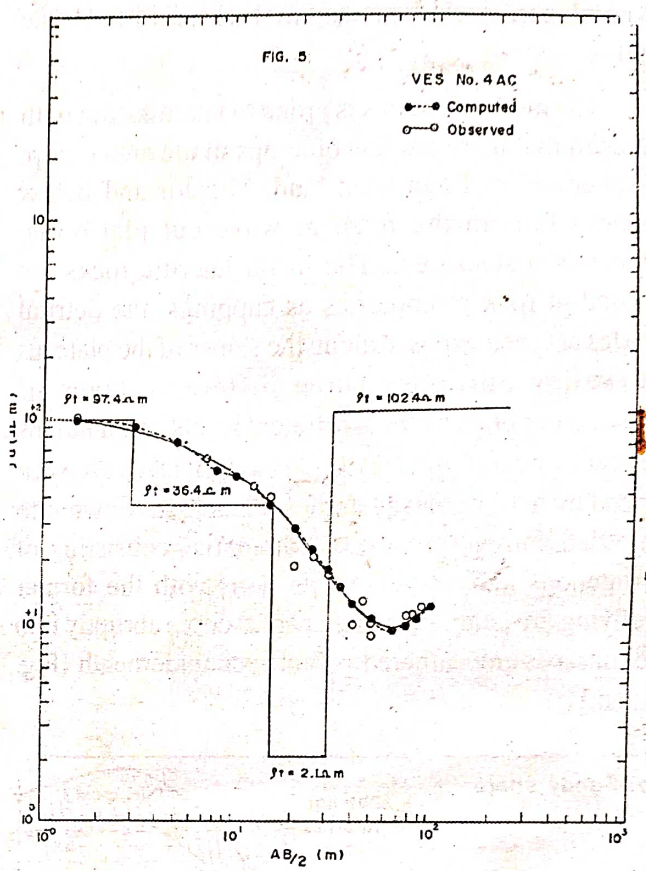


Fig.5 : Vertical Electrical soudning of Goa shore

is encountered at a depth range of about 15m to 32m below ground where the resistivity is as low as 2 Ohm-m.

Conclusion

It is shown that the geoelectrical profiling can be effectively used to locate the freshwater pockets very close to the sea. It is to be emphasised in this context that the drinking water needs of the rural people in the coastal tracts of Goa has been a neglected matter. However this type of survey conducted at regular intervals of time can provide invaluable information about the quantity and distribution of fresh groundwater at a particular settlement and this can be used to plan for more number of open wells to meet the drinking water demands of the poor particularly during summer seasons.

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