Barisal University Journal Part 1, 4(2):351-360 (2017) ISSN 2411-247X

RESISTIVITY SURVEY AND SALINE WATER INTRUSION IN AND AROUND COX'S BAZAR IN BANGLADESH

Muhammad Risalat Rafiq[1*], Kazi Matin Ahmed[2], A.S.M. Woobaidullah[2] and Ashraf Ali Seddique[3]

[1]*Department of Geology and Mining, University of Barisal, Barisal 8200*

[2]*Department of Geology, University of Dhaka, Dhaka 1000*

[3]*Department of Environmental Science and Engineering, Jatiya Kabi Kazi Nazrul Islam University, Trishal, Mymensingh*

Abstract

Saline water intrusion has become major concern in Cox's Bazar town over recent years. Due to presence of main aquifer in contact with seawater of the Bay of Bengal, there is risk of contamination to aquifer along coastline. The study has been carried out to assess the saline water intrusion in and around Cox's Bazar town applying resistivity method. Vertical Electrical Sounding (VES) and Constant Separation Traversing (CST) were carried out at 23 points. Therefore, CST or profiling data were compared with bore logs from five locations for more precise interpretation. Acquired data has been interpreted using RES2DINV software. A dominant decreasing trend of resistivity with depth is observed from the profiling data. Moreover, resistivity values decrease easterly at shallow depth while points having resistivity values less than 10 Ωmeter delineate intrusion points. Besides, shallow aquifers were found more prone to saline water intrusion. In addition, results of the profiling demarcate the fresh-saline water interface about 25 m inland from the coast, which is indicative of saline water intrusion at a number of locations in Cox's Bazar town. Excessive pumping of groundwater alongside reduction of natural recharge due to covering of buildings, pavements etc. might have resulted in saltwater intrusion in this locality.

Keywords: Geophysical investigation, Saline water intrusion, Aquifers.

Introduction

Groundwater is one of the most important and essential natural resources for the survival of human beings. Due to rapid urbanization and industrialization, this groundwater is

Corresponding author's e-mail: risalat@barisaluniv.ac.bd

being adversely contaminated by saline water intrusion, in the coastal regions of Bangladesh. The movement of saline water into a freshwater aquifer or surface reservoir is known as saltwater intrusion, and if the source of this saline water is sea water, then this process is known as seawater intrusion. Aquifers in hydraulic connection with saline or seawater may contain saltwater in adjacent portions while other portions of the aquifer may still contain fresh water. Salinity increases in inland from November due to reduction of fresh water flows and intrude up to 150 km inland in the lower Meghna in the South East and up to 290 km up Passur River in the south–west of the country (Rahman et al., 2014). The issue of salt–fresh water intrusion has been a long-standing problem and was addressed by many researchers earlier by various methods. Frohlich et al. (1994) studied the groundwater pollution in coastal environment by employing electrical resistivity method. Prominent heterogeneity of the subsurface sediments and water quality changes in both vertical and horizontal direction in south-west coastal belt in Satkhira was found by resistivity sounding survey (Woobaidullah et al., 1996). Direct current (DC) resistivity method was effectively highlighted to distinguish the fresh-saline water interfaces while demarcating suitable areas for groundwater development in Nigeria (Adepelumi, 2008; Adepelumi et al., 2009). A total of twelve VES revealed that the groundwater quality varies from poor polluted saline water saturated sand/clay through intermediate water quality clayey sand/sand to freshwater sand in oniru, lagos state (Adeoti et al., 2010).

Cox’s Bazar, the longest sandy beach of the world is getting more familiar with the world every day and people from the different corners of the world show their interest on it. Although tourism makes a greater contribution economically, it affects the coastal ecosystem as well as water. In Cox’s Bazaar town, rapid growth of population is associated with urbanization; expanding tourism and industrialization that contribute significant increase of fresh water demand-the aftermath is excessive pumping in coastal aquifers. As a result, sea water intrusion has become an alarming phenomenon. Nonetheless, very few studies have been carried out so far to delineate the saline water intruded areas in this study area. From this perspective, an attempt was carried out in this disquisition to assess horizontal and vertical extent of saline water intrusion in the Cox’s Bazar town, and to identify probable areas of mixing of saline water with fresh groundwater.

Materials and Methods

The study area lies between N 21° 28' 50" to N 21° 23' 28" and E 91° 56' 38" to E 92° 2' 30" (Fig. 1). It is famous for its longest sandy beach (about 125 km). The area is included in the Survey of Bangladesh topo sheet no. 84 C/3. It has a total area of about 6.85 km^2 with a population of 51,918. The area is bounded in the north and the east by Bakkhali river, and in the west by the Bay of Bengal, and Jhilwanja union in the south.

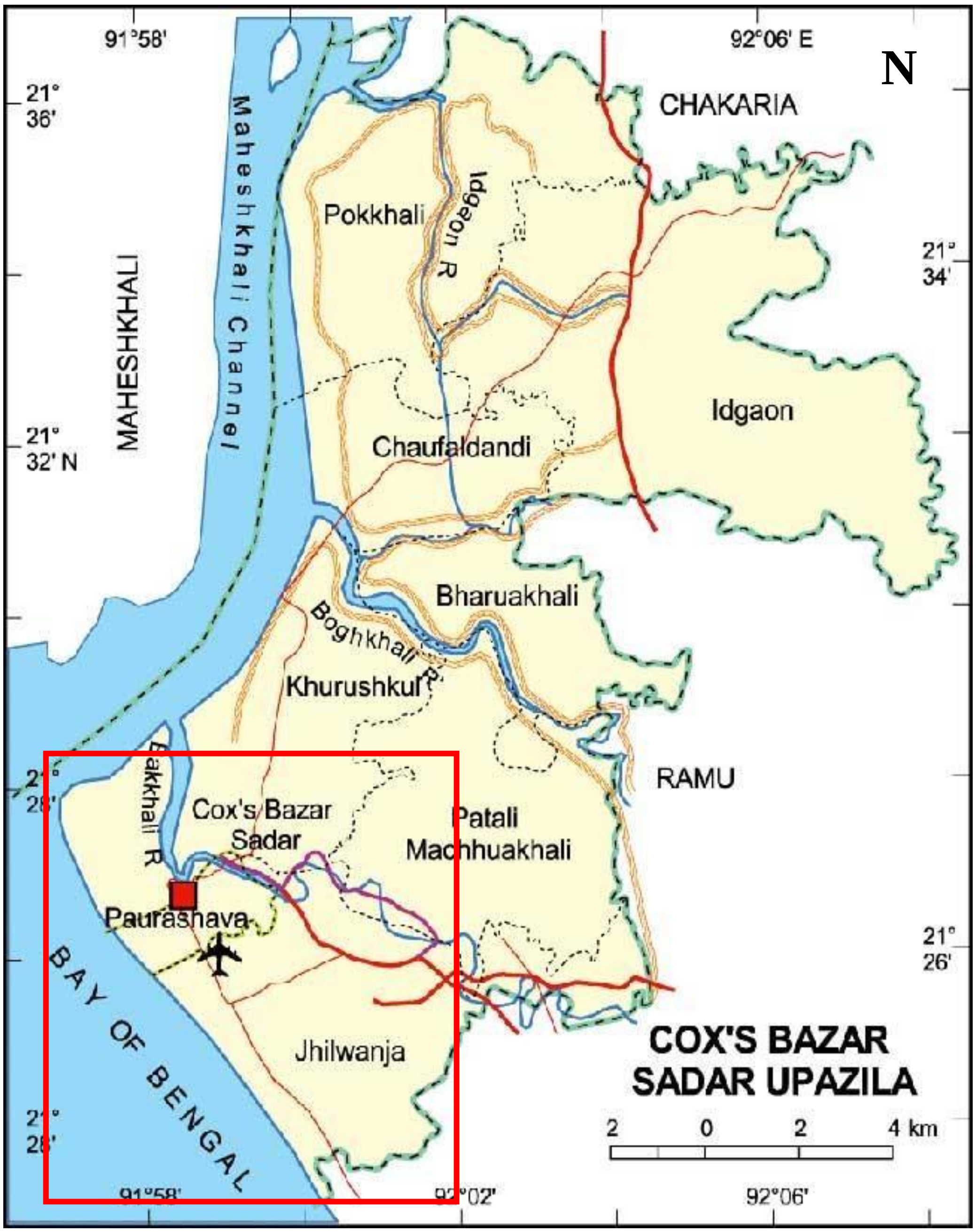

Fig. 1. Location map of Cox's Bazar Sadar Upazila. The sudy area has been indicated by red colored rectangle on the map.
(Source: www.hellobangladeshbiz/bangladesh/district/cox's_bazar.html)

Resistivity survey has long been carried out as a reconnaissance survey for exploration of suitable freshwater zones in the subsurface. A resistivity survey was carried out in Cox's Bazar town from 12 March 2012 to 16 March 2012. Profiling/ CST and VES was used as a combined approach to delineate lateral heterogeneity of resistivity in porous media at a particular depth along a particular traverse line. Total, 23 points have been selected to acquire sounding and profiling data along the N-W and E-W transect (Fig. 2 and 3). To perform Vertical Electrical Sounding, Schlumberger array was used, while Wenner array was used to perform CST. CST data were used for depth profiling in combination with bore log data. The main purpose of using bore log data was to validate resistivity data by cross-checking. After data acquisition, both profiling and sounding data were manually entered using RES2DINV software. Therefore, these data were processed automatically using this software, output of which was named as "profiling section". Both geo-electric and lithological cross sections were constructed using Rockworks software.

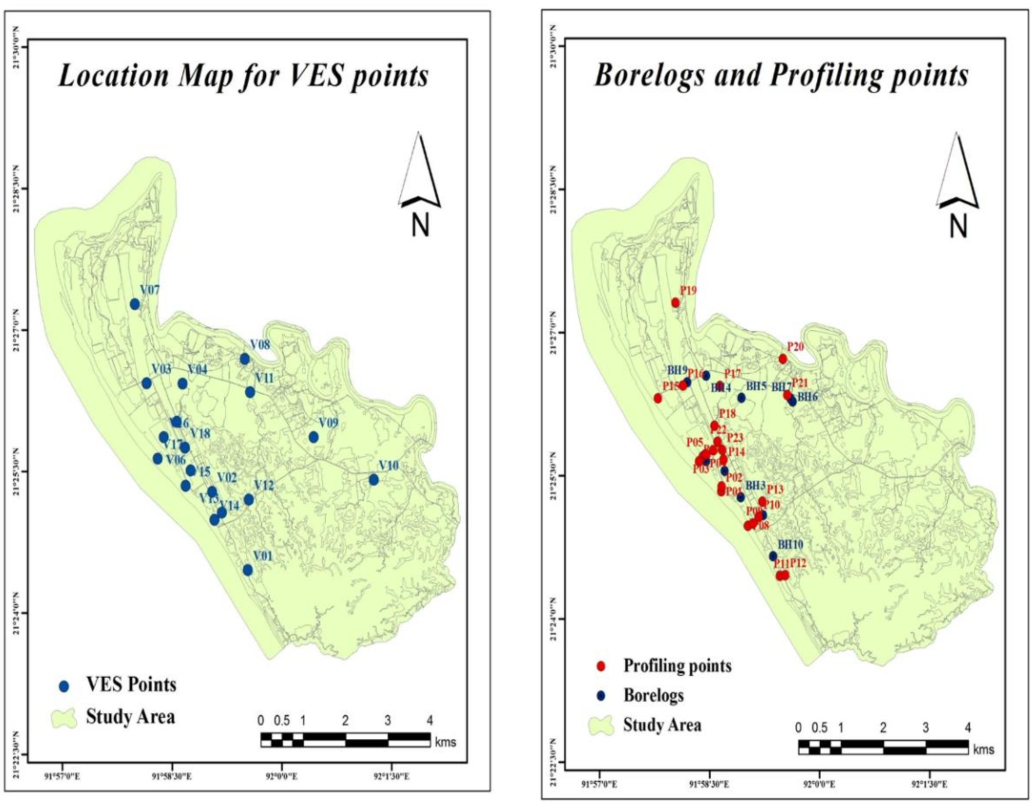

Fig. 2. Location map of Cox's Bazar Sadar Upazila. The sudy area has been indicated by red colored rectangle on the map.

VES data analysis

VES data were processed in two phases. At first, measured apparent resistivity was plotted in the log-log paper against half of the electrode spacing and a curve was constructed. Secondly, data processing and interpretation was performed in Rockworks software to generate geo-electric cross section. Geo-electric cross-sections (Fig. 3) for both of the cross-section lines were drawn using Rockware software. The east-west and NW-SE geo-electric cross sections illustrates lithologic variation based on resistivity values. Resistivity values in the study area varied from 7 to 1000 Ωm.

CST data analysis

After assembling profiling data from the study area, data were manually entered into the using software named RES2DINV. Fig. 2 shows 23 profiling locations in the study area where gathered acquired data were analyzed and interpreted in order to assess the seawater intrusion near the coast. Very low resistivity values have been found at five locations in and around Cox's Bazar town. To validate resistivity value it is utmost important to make correlation with adjacent bore logs. Moreover, to understand the significance of low resistivity value, was calibrated it is necessary to analyze with the adjacent bore logs.

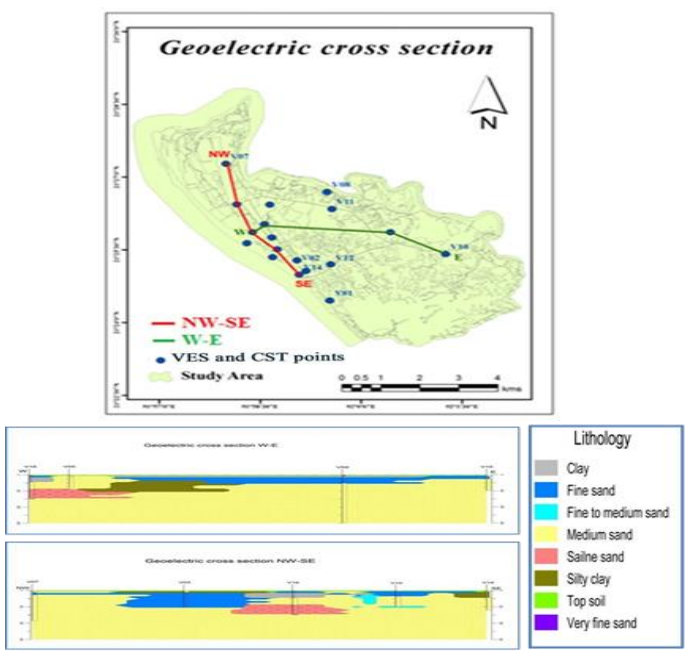

Fig. 3. Geoelectric cross section of the study area along northwest-southeast (up) and west-east (down) direction.

Summary of the combined analysis of profiling and bore log data are listed below-

i) In recent beach, profile section shows (Fig. 4) low resistivity value (less than 10 Ωm) at depth of about 10 m about 25 m away from the beach. Adjacent bore log BH3 shows (Fig. 9), fine to medium sand occurs at depth of about 10 m. It might be possibility of seawater intrusion at this point.

ii) At Laboni point (Paleo beach), low resistivity values (about 6 Ωm) was found (Fig. 5) at depth of more than 20 m about 35 m far away from coastline. Adjacent bore log BH08 shows (Fig. 9), fine to medium sand occurs at depth of more than 24 m. There is possibility of seawater intrusion at depth of 24 m.

iii) At Kalatali recent beach, low resistivity value (less than 5 Ωm) was located at depth of 5 m (Fig. 6) about 28 m away from the beach. Both the adjacent bore log BH1 and BH10 (Fig. 9) confirms fine to medium sand at about 5 m depth. It may be probability of seawater intrusion at Kalatali point.

iv) Kalatali paleobeach also showed low resistivity value at near surface (Fig. 7) around 6 m away from beach. However, adjacent bore log (Fig. 9) confirms clay at that depth.

v) Diabetic points located at the northern part of the study area showed resistivity value of less than 10 Ωm (Fig. 8) at depth of 30 meter about 35 m far from coast line. Adjacent bore log BH09 (Fig. 9) confirms fine to medium sand at that depth. Seawater might be intruded at that depth.

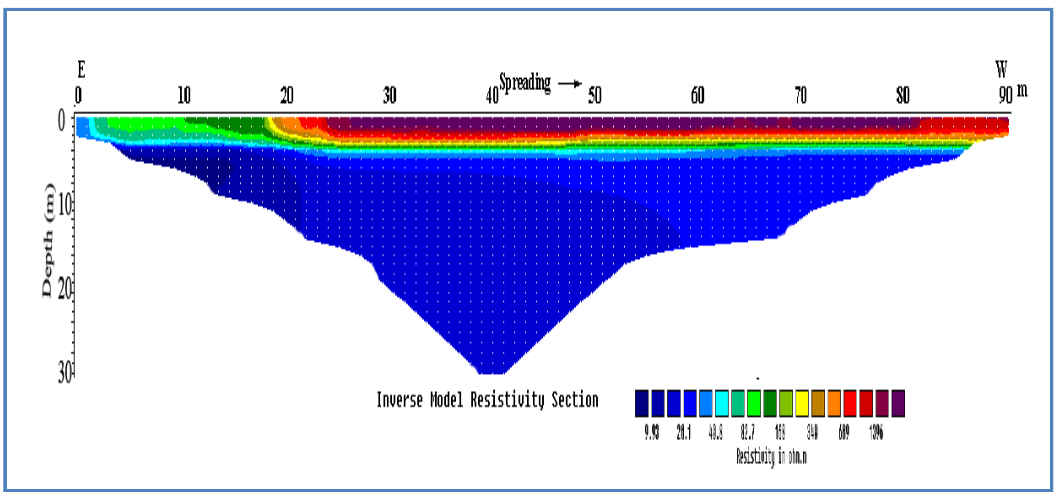

Fig. 4. Profile 01- Profile section of Recent Beach along E-W direction.

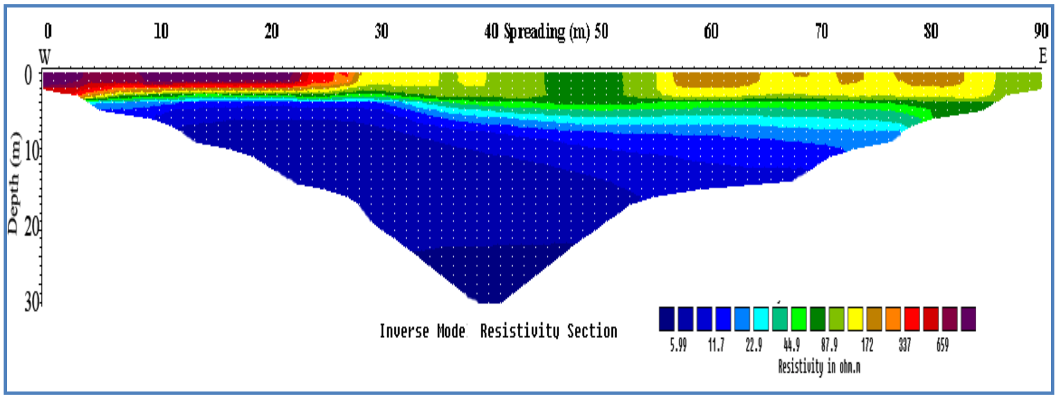

Fig. 5. Profile 05- Profile Section of Laboni Point along W-E direction.

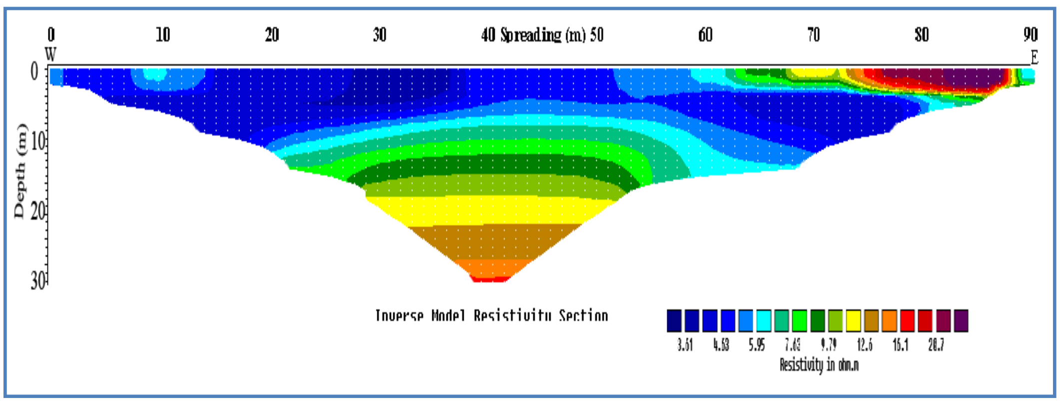

Fig. 6. Profile 08- Section of Kalatali recent beach along W-E direction.

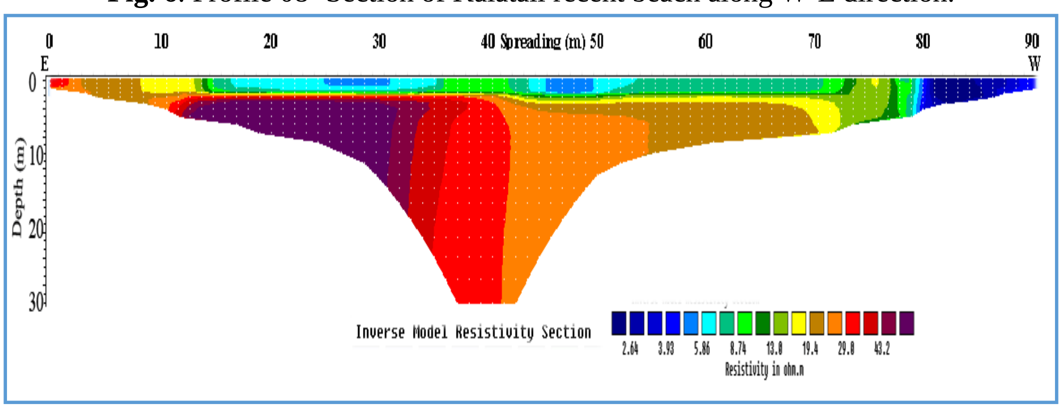

Fig. 7. Profile 11- Profile section of Kalatali along E-W direction.

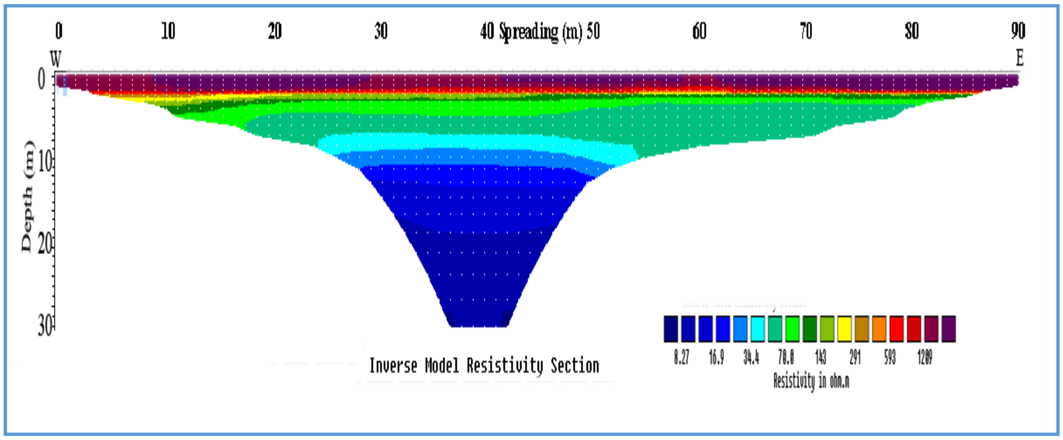

Fig. 8. Profile 15- Profile Section of Dibetics Point along W-E direction.

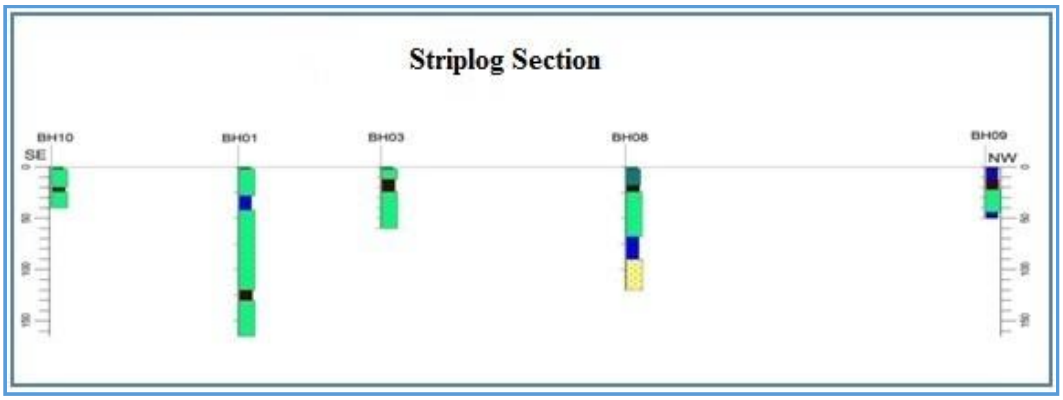

Fig. 9. Bore logs of points of the study area near to profiling points.

Results and Discussion

Fig. 3 shows that, medium sand dominates over the section, where resistivity values ranging from 34 to 1000 Ωm. This high range of values barely confirmed better water quality. However, it can be assumed as fresh water bearing formation. This fresh water bearing formation is found at a depth of more than 150 m. Away from the N-W part; silty clay layer is observed at very shallow depth. Silty clay layer shows resistivity value ranging 11 to 13 Ωm. Fine sand shows resistivity value from 18 to 27 Ωm that indicates brackish type of water. Fine to medium sand is observed at depth of more than 50 m, which shows resistivity value ranging 25 to 32 Ωm and that indicates good water quality. At the middle of this cross-section sand unit is observed at depth more than 100 m which shows resistivity value less than 10 Ωm that indicates saline-water intrusion in this part. (Fig. 3)

The east-west cross-section (Fig. 3) illustrates gradually finer sand towards the eastern direction. Very close to the beach, sand unit occurred at depth of about 90 m shows resistivity values less than 10 Ωm indicating sea water intrusion near beach.

Conclusions

Saline water intrusion has become evident at a number of locations and can become a major problem in Cox's Bazar town due to over-exploitation of groundwater for various purposes. This research was carried out with the objective of assessing the extent saline water intrusion in Cox's Bazar town.

Bore logs and resistivity data are used to interpret the subsurface geology. Resistivity results reveal a major inclination of decreasing resistivity with depth indicating increase of salinity. VES data shows the lithological variations against resistivity value and demarcate the study area as- a) unconsolidated materials resistivity value ranging from 100-1934 Ωm, b) silty clay and clay shows values between 7 to 13 Ωm, c) fine sand with values of 15 to 30 Ωm d) medium sand with great rang of 34 to 1000 Ωm. Analyses of profiling data indicate the fresh-saline water interface located about 25 m inland from coastline.

Two vital factors responsible for inducing saline water intrusion in Cox's Bazar town are the excessive pumping of groundwater demand and reduction of natural recharge due to covering more and more areas with buildings, pavements etc. The aquifer is recharged mainly from the hills to east of the Cox's Bazar town and there has been recent development of housing areas on top of the hills. This may also results into lower natural recharge and higher amount of surface runoff and can further accentuate the magnitude of saline water intrusions.

W-E cross section (Fig. 3) illustrates gradually finer sand towards the eastern direction. Very close to the beach, sand unit occurred at depth of about 90 m shows resistivity values less than 10 Ωm indicating sea water intrusion near beach.

Acknowledgements

The authors would like to take the opportunity to extend special thanks to Sukhen Goswami and Atikul Haque Farazi of University of Barisal for their cooperation in completing the paper.

References

Acworth. R. I. 2001. Electrical Methods in Groundwater Studies, UNSW Groundwater Centre.

Adeoti, L., O. M. Alile and O. Uchgbulam. 2010. Geophysical investigation of saline water intrusion into freshwater aquifers: A case study of Oniru, Lagos State, Nigeria. Scientic Research and Essays. **5**:248-259.

Adepelumi, A. A. 2008. Delineation of saltwater intrusion into the freshwater aquifer of Lekki Peninsula, Lagos, Nigeria. Environmental Geology. **56**:927-933

Frohlich, R. K., D. W. Urish, J. Fuller and M. O. Reilly. 1994. Use of geoelectrical method in groundwater pollution surveys in a coastal environment. Journal of Applied Geophysics. **32**:139-154.

Kearey, P. M. 2002. An Introduction to Geophysical Exploration, Brooks & Hill. pp 183-197.

Keller G. V. and F. C. Frischnesht, 1966. Electrical methods in geophysical prospecting Maiskhali and Cox's Bazar-Teknaf coast of the Bay of Bengal. The Journal of NOAMI. **11**:1-10

Mizanur M. and A. K. Bhattacharya. 2014. Saline water intrusion in coastal aquifers: A case study from Bangladesh. IOSR Journal of Engineering. **4**:7-13.

Rider, M. H. 1986. The Geological Interpretation of Well Log, pp. 35-38.

Woobaidullah A.S.M., M. Rahman, A. Romer and R. Arndt. 1996. Geoelectric resistivity survey for suitable freshwater aquifer identification in the coastal belt of south-west Bangladesh. Jahrbuch Der Geologischen Bundesanstalt. **1**:127-137