Application of Resistivity and Bore Log Data for Fresh Groundwater Exploration in Sandwip Offshore Island, Bangladesh

Md. Ahsan Habib[1*], Abu Syed Mohammed Faisal[1], Md. Azahar Hossain[1], Salma Akter[1]

[1]Environmental Geology and Natural Hazard Assessment Branch, Geological Survey of Bangladesh (GSB), Dhaka, Bangladesh

(*Corresponding E-mail: gsb.habib@gmail.com)

Abstract: The Sandwip an offshore island of Chittagong District, Bangladesh, requires a substantial amount of fresh groundwater mainly for industrial and household uses. This study integrates resistivity and bores log data to explore fresh groundwater potential in a complex deltaic environment. A total of 15 Vertical Electrical Soundings (VES) and two Electrical Resistivity Tomography (ERT) profiles were acquired using Schlumberger and Wenner arrays. Resistivity data, interpreted through computer modeling and calibrated with borehole lithology, reveal highly heterogeneous subsurface conditions with frequent aquifer–aquitard alternations. The topsoil (2.35–12.16 Ωm) is underlain by silty clay (Aquitard 1). A shallow aquifer (Aquifer 1) occurs at depths of 10–60 m, composed of fine to medium sand with resistivity of 14.51–94.24 Ωm. A second aquitard (5–61 m thick) separates Aquifer 1 from an intermediate aquifer (Aquifer 2), encountered at 60–130 m with a thickness of 4.15–82.13 m. A deeper clay unit (Aquitard 3) underlies Aquifer 2. Although sand layers are present, both aquifers exhibit resistivity signatures of brackish to saline water, with only isolated pockets of freshwater. Hence, large-scale groundwater development within 130 m depth appears limited. Future investigations should employ extended electrode spreads to explore aquifers below 300 m, where more prolific freshwater reserves may occur.

Keywords: ***Resistivity, Bore Log, Groundwater, Exploration, Offshore.***

Introduction

Bangladesh is one of the most densely populated countries in the world, where groundwater is a primary source for domestic, agricultural, and industrial use. Coastal islands such as Sandwip face acute freshwater scarcity due to salinity intrusion, over-extraction, and climate-induced hazards including tidal surges and cyclones (Uddin et al., 2014; Zahid et al., 2016; Woobaidullah et al., 2020). Reliable aquifer characterization is therefore essential for sustainable groundwater management. This study applies an integrated geo-electrical and borehole approach to evaluate groundwater potential in Sandwip Island, with emphasis on identifying freshwater aquifer zones.

Methodology

A total of 15 Vertical Electrical Soundings (VES) and 2 Electrical Resistivity Tomography (ERT) profiles were conducted using Schlumberger and Wenner arrays. The maximum current electrode separation reached 800 m for VES and 100 m for ERT. Data interpretation involved manual curve matching followed by inversion using 1×1D software. A total of 21 bore log data from the study area were used to calibrate resistivity models and confirm lithological units.

Results and Interpretation

The resistivity results reveal a heterogeneous subsurface typical of deltaic environments. The topsoil (0.49–6.65 m thick) shows resistivity values between 2.35 and 12.16 Ωm. Beneath this, Aquitard 1 (silty clay) has resistivity of 2–13 Ωm with thickness of 1.40–10.55 m. Aquifer 1 (10–60 m depth) comprises fine to medium sand with resistivity values of 14.51–94.24 Ωm. Aquitard 2, a silty clay layer 5–61 m thick, separates Aquifer 1 from Aquifer 2. Aquifer 2 occurs at 60–130 m depth with thickness ranging from 4.15 to 82.13 m, composed of fine to medium sand, but showing resistivity of 2.4–12.8 Ωm, indicating brackish to saline water saturation. A deeper clay layer (Aquitard 3) underlies Aquifer 2. ERT profiles confirmed lateral lithological variability and the presence of isolated freshwater sand pockets.

Discussion

The combined analysis of resistivity and bore log data indicates highly irregular aquifer–aquitard distribution due to deltaic deposition. Resistivity ranges of saline sands overlap with clay, underscoring the necessity of bore log calibration. Both shallow and intermediate aquifers largely contain brackish to saline water, limiting groundwater development. Similar conditions have been reported in other coastal regions of Bangladesh, highlighting the broader challenge of freshwater scarcity in deltaic aquifers.

Conclusion

This study uses comprehensive fieldwork to analyze the availability and sustainability of groundwater resources in Sandwip island. In this area the surface water and groundwater are both accessible for usage in this Upazila. Considering groundwater exploration, the electrical resistivity sounding method is well recognized as an effective geophysical tool. The freshwater aquifer in the area was discovered using Vertical Electrical Sounding which measures the apparent resistivity of the subsoil over an area of 800 meters.

The lithological cross-sections, constructed from Vertical Electrical Sounding (VES) data and borehole drilling results, confirm that the subsurface is primarily composed of sand and clay, with minor occurrences of silt. However, their distribution is highly irregular both laterally and vertically, reflecting frequent facies changes. These findings align with the three-tier coastal aquifer system proposed by Aggarwal et al. (2000) for Bangladesh, which consists of a shallow aquifer (Aquifer 01), an intermediate aquifer (Aquifer 02), and a deeper aquifer (Aquifer 03).

The study confirms saline water intrusion in both the shallow and intermediate aquifers, as evidenced by low resistivity values. This is further exacerbated by the uneven lithological distribution of the first aquitard, which allows limited hydraulic connectivity between Aquifer 01 and Aquifer 02, facilitating saline intrusion into deeper formations. While evidence suggests the potential existence of a deeper freshwater aquifer (Aquifer 03) at approximately 150 m depth, its extent remains uncertain due to the limitations of the current investigation.

To better understand the deep aquifer potential and evaluate the presence of freshwater reserves beyond 150m, future research should employ deep geophysical surveys and hydrogeochemical analysis. Expanding the investigation to depths beyond 300 m could provide valuable insights into potential sustainable groundwater resources for the region.

Recommendations

- Conduct deeper resistivity and hydro chemical surveys (>300 m).
- Implement continuous monitoring of salinity in shallow aquifers.
- Apply managed aquifer recharge methods such as rainwater harvesting.
- Enforce controlled groundwater abstraction policies to prevent saline intrusion.

References

Aggarwal, P. K., Choudhury, A., Ramaswamy, V., and Gupta, S. K. (2000). Isotope hydrology of groundwater in Bangladesh. Journal of Hydrology, 234, 1–16.

Uddin, M. J., Rahman, M., Chowdhury, T., and Hossain, M. S. (2014). Salinity intrusion and groundwater vulnerability in coastal Bangladesh. Environmental Earth Sciences, 72, 1–12. DOI:10.1007/s12665-013-2931-5

Woobaidullah, A. S. M., Rahman, M., Hasan, M., and Karim, M. R. (2020). Geo-electrical resistivity survey for fresh groundwater investigation in Mirsharai Economic Zone, Chittagong. Journal of Nepal Geological Society, 60, 181–194. DOI: 10.3126/jngs.v60i0.31262

Zahid, A., Rahman, M., and Hossain, M. (2016). Groundwater resources of Bangladesh. Journal of Groundwater Studies, 10 (2), 45–59.