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Preliminary geophysical study for groundwater exploration in the eastern region of Islamabad

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ABSTRACT

Geophysical study was carried out in the area lying to the east of Islamabad to identify potential aquifers and to establish the relationship between the geoelectric and hydrogeologic parameters. Electrical resistivity survey using the Schlumberger electrode configuration was carried out at 32 stations. Data processing and interpretation were done using a PC based software. The true resistivity and thickness of various subsurface horizons were interpreted in terms of geological columns and cross-sections to reveal the presence of clay, sand, gravel and boulders as the subsurface lithology. The wide occurrence of gravels and boulders suggest that most of the regions in the project area represent the promising zone of groundwater. Both confined and unconfined aquifers have been encountered. The resistivity information was used to plot Dar-Zarrouk curves across selected profiles in order to determine the electrical behaviour of the aquifer. These curves show that the surficial layer is composed of material of high resistivity while the second layer constitutes the aquifer having high longitudinal conductance. Finally, statistical analyses involving linear regression were carried out to find out the relationship between electric and hydraulic properties of the aquifers. The results indicate that there is no significant relationship between the two parameters. All the results were compiled to demarcate promising groundwater drill sites.

INTRODUCTION

A resistivity survey was conducted in an area of 12 km^2 in the eastern region of Islamabad for groundwater. The area under investigation is bounded by 33° 42' 33" to 33° 44' 17" N latitudes and 73° 8' 32" to 73° 11' 2" E longitudes (Fig. 1). Schlumberger electrode configuration was used at 32 stations, out of which data from three stations were discarded by the automatic processing software as they were highly distorted. The subsurface lithology in the area consists of clay, sand, gravels and boulders. Geoelectric and hydraulic parameters were correlated to examine the hydrological condition of aquifers.

GENERAL GEOLOGY

Islamabad is situated in the north-east of the central Potwar plateau. Soan geosyncline, forming the lower foothills of outer Himalaya, is the major tectonic feature which dominantly controls the topography of the investigated area. The altitude varies from 572 m to 610 m above msl. The age of the underlying rocks distributed in Islamabad ranges from Tertiary to Jurassic. Most of the area is covered by the Quaternary alluvial deposits mostly derived from Mergala hills. The Quaternary deposit consists of boulders, gravels, pebbles, sand and clay. Its thickness varies from 250-400 m. The aquifer consists of widely spread gravels with sand and locally confined by impermeable clay layers.

DATA ACQUISITION

Vertical electrical resistivity sounding (VES) measurements were carried out at 32 stations using the Schlumberger configuration with a maximum spread of 400 m. The VES stations were selected at random due to topographic variations. For data acquisition, a digital ABEM Terrameter Signal Averaging System (SAS 300C) equipped with an electrode selector system was used. VES curves were plotted from the acquired resistivity (ρ_a) data using a computer software.

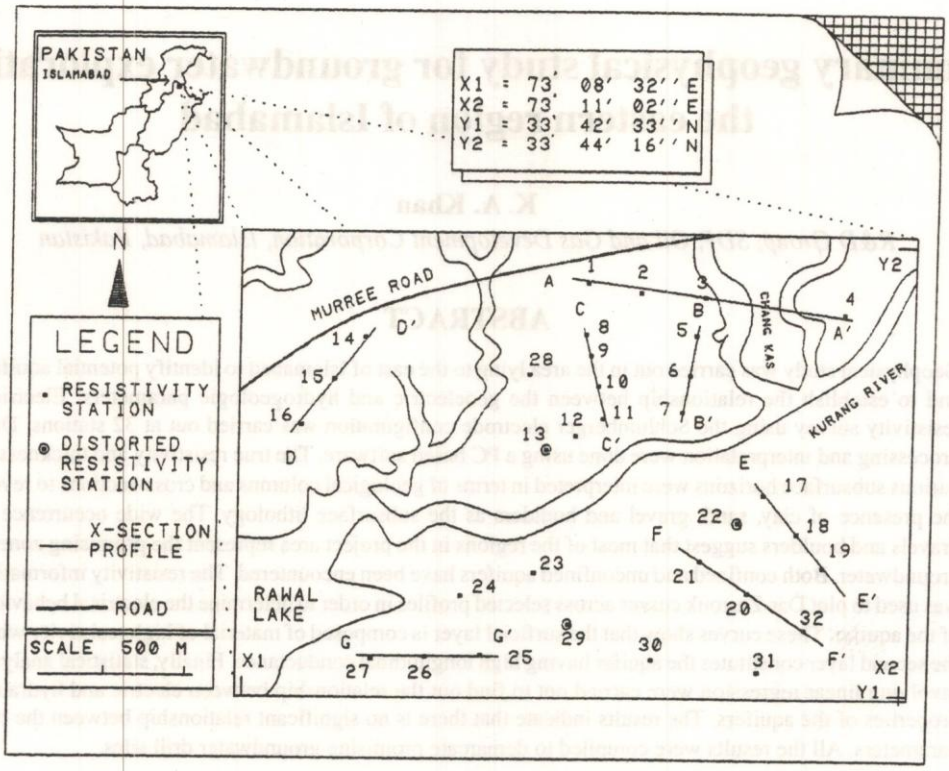

Fig. 1: Location map of the study area.

DATA PROCESSING AND INTERPRETATION

The apparent resistivity (VES) data were used to compute a 3D resistivity grid matrix for plotting an apparent resistivity cube (Fig. 2). The field VES data at each station were processed on a computer with 'Automatic Curve Matching (ACM)' software which utilizes the partial curve matching technique (Khan and Khan, 1995). During the processing, the data pass through the dirty point filter (Khan, 1994a) to remove distorted data and then analyzed by the slope model (Khan, 1993) for automatic determination of the number of layers and the curve type (i.e., A, K, H, Q, HK, etc.). Finally, the data are smoothed and resampled using the sampling interval of the theoretical curves in order to generate a smooth curve (Khan, 1994b). The final curve is matched with an album of digitized theoretical curves for Schlumberger sounding (Khan, 1992) originally computed for horizontally stratified media by Orellana and Mooney (1966). The curve matching involves an iterative procedure of matching the coefficients of a portion of the observed curve with theoretical curves. This iterative comparison continues unless a best match is found. The iterative procedure is then repeated for the next portion of the observed curve. This process continues until the whole observed curves are matched and true resistivity and depth of each layer is computed. These data, in turn, are matched with the resistivity-lithology tables to get a completely interpreted geological model. Twenty nine out of 32 curves were processed by using this procedure on the basis of data quality analysis. Fig. 3 shows one of the VES curves and its computerized interpretation.

The VES curves obtained from the 29 processed resistivity stations represent 3, 4 and 5 layer cases. The resistivity-lithology tables were developed on the basis of on-site hydrogeological information and correlation with the pre-existing resistivity curves obtained by Department of Earth Sciences, Quaid-i-Azam University, Islamabad. The interpreted lithological columns for each VES curve were used

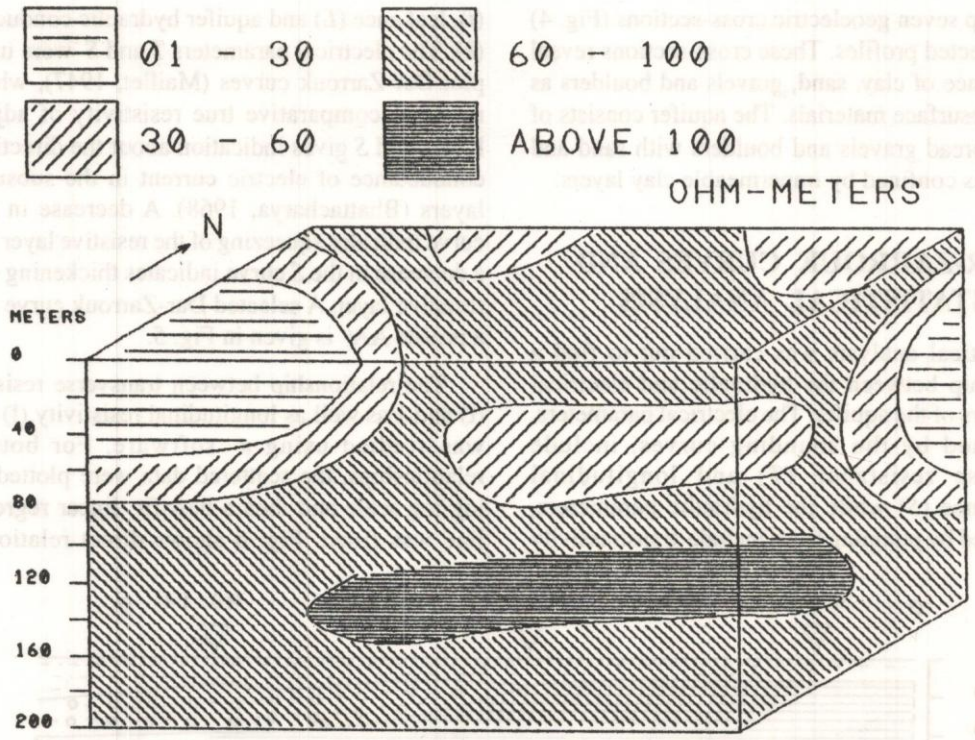

Fig. 2: 3D apparent resistivity distribution curve.

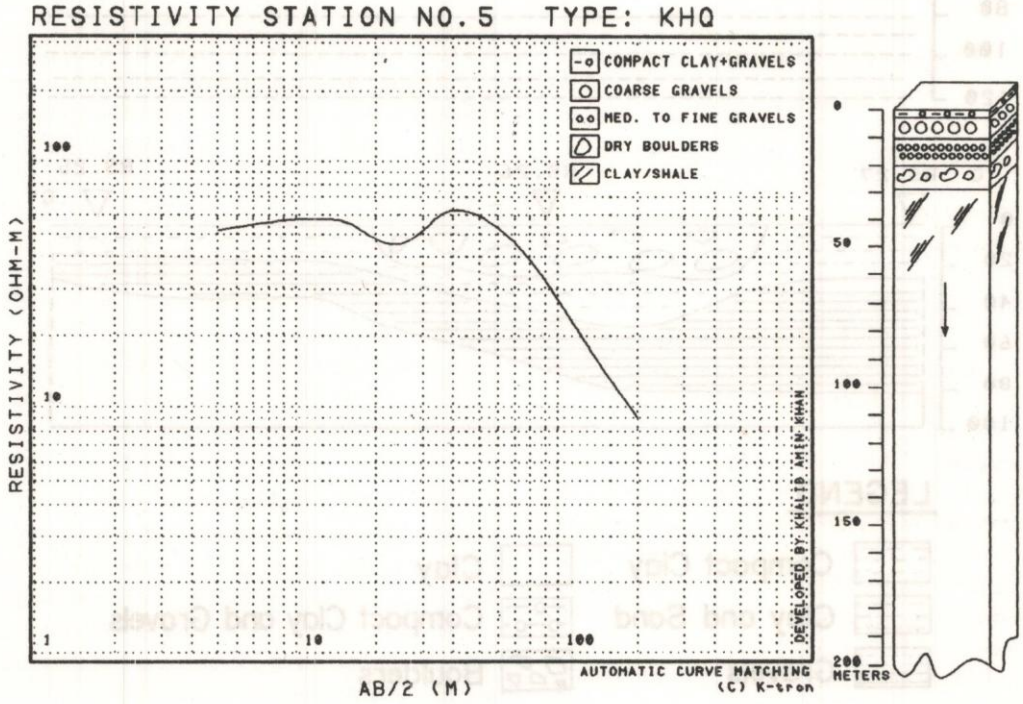

Fig. 3: A VES curve and its computerized interpretation.

to develop seven geoelectric cross-sections (Fig. 4) along selected profiles. These cross-sections reveal the presence of clay, sand, gravels and boulders as major subsurface materials. The aquifer consists of widely spread gravels and boulders with sand and sometimes confined by impermeable clay layers.

DAR-ZARROUK CURVES AND STATISTICAL ANALYSIS

Statistical analysis was carried out to find a relationship between the hydraulic and electrical parameters of the aquifer. The electrical parameters, determined by the sounding curves, include transverse resistance (T) and longitudinal conductance (S) while the hydraulic parameters, determined by pumping tests, include transmissivity (t), leakance (L) and aquifer hydraulic conductivity (k). The electrical parameters T and S were used to plot Dar-Zarrouk curves (Maillet, 1947), where T refers to comparative true resistivity of adjacent layers and S gives indication about the direction of conductance of electric current in the subsurface layers (Bhattacharya, 1968). A decrease in the T curve indicates squeezing of the resistive layer while a decrease in the S curve indicates thickening of the resistive layer. A selected Dar-Zarrouk curve along a profile AA′ is given in Fig. 5.

The relationship between transverse resistivity (t) and k as well as longitudinal resistivity (l) and k was studied using a software. For both the relationships, the scattered data were plotted on a log-log scale and then a best-fit linear regression line was fitted. Fig. 6 shows direct relationship

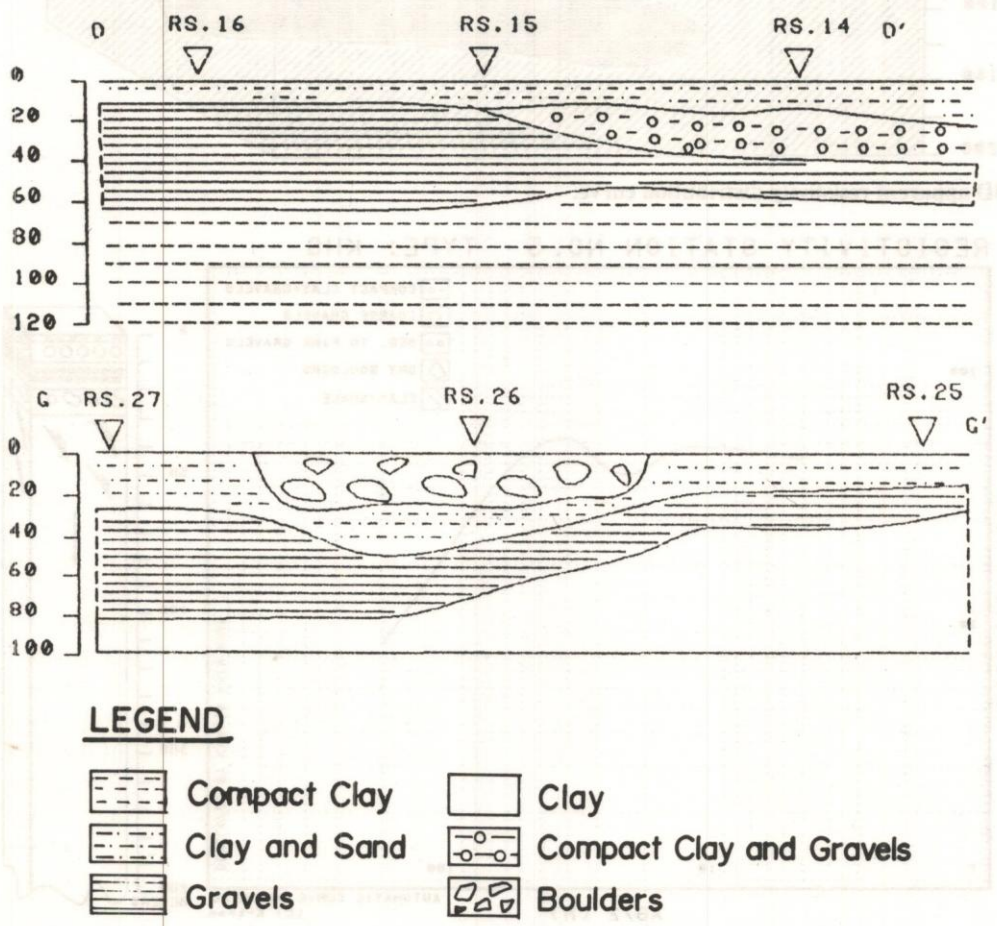

Fig. 4: Geoelectrical cross-sections along selected profiles. Note: horizontal distance not to scale.

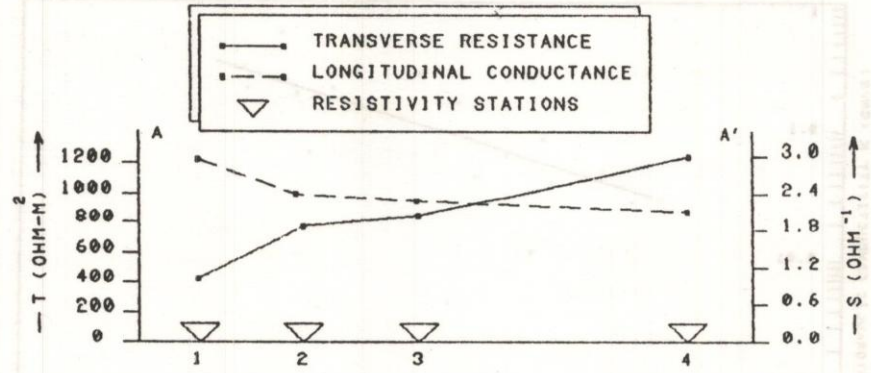

Fig. 5: Dar-Zarrouk curves along profile A-A' (Fig. 1).

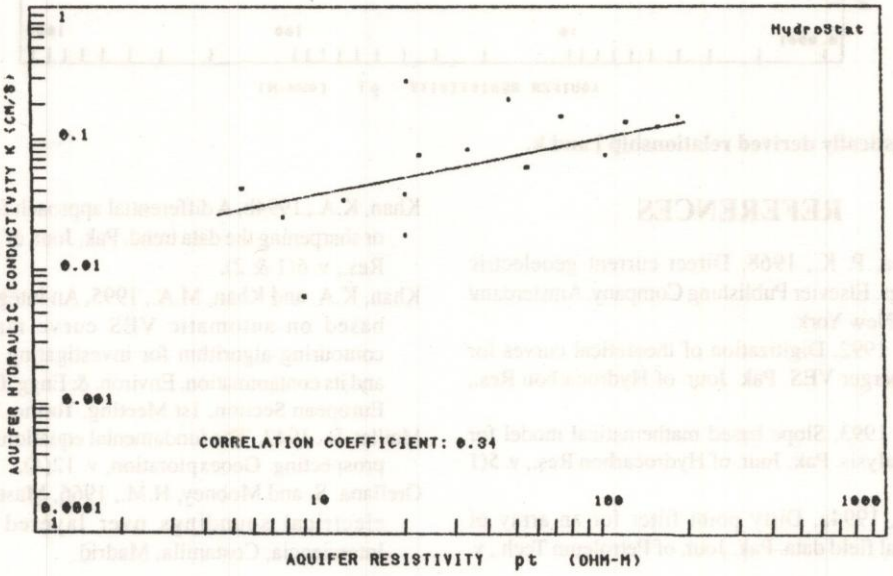

Fig. 6: Statistically derived relationship t and k.

between t and *k*. The lower value of the coefficient of correlation (0.34) indicates no significant correlation between the two parameters. Similarly, Fig. 7 shows a direct relationship between l and *k* along with a correlation coefficient of 0.31 indicative of poor correlation between the two parameters.

CONCLUSIONS AND RECOMMENDATIONS

The existence of both confined and unconfined aquifers is suggested in the study area. The aquifer is mostly composed of gravels, boulders and sand which are sometimes confined by impermeable clay layers. Most of the investigated area consist of promising zones for groundwater. The Dar-Zarrouk curves indicate that the surficial layer is composed of high resistive material while the aquifer material generally falls in the second layer having high longitudinal conductance. The statistical analysis indicates that there is no significant relationship between aquifer hydraulic and electrical parameters. Investigation tube wells are recommended at the resistivity stations on the basis of this study. After successful completion of investigation tube wells, the production well can be sunk.

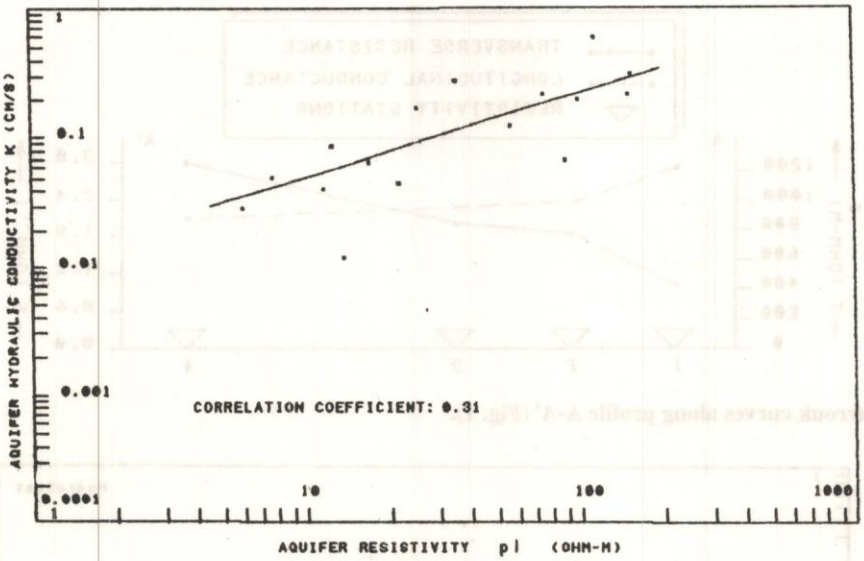

Fig. 7: Statistically derived relationship l and k.

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