Water Storage in Weathered-fractured Coupled Aquifer from Electrical Resistivity Logs and Impact of Climate Change on Resistivity

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Water resources in hard rock is a main problem to be tackled by the geoscientists throughout the world where exits enormous complexity and heterogeneity. The amount of water available in the rock matrix of the coupled (weathered-fractured) aquifer depends on the saprolite (weathered granite) thickness and porosity as well as the associated zones of dense fracturing. The goal is to find out the available water storage/reserve using geophysical methods or other hydrological tools within the said coupled aquifer system.

In the present research work, subsurface electrical resistivity logging at 16 sites was performed using the abandoned borewells, depths ranging from 44 m to 86 m. The borewells are located between 78^{o} 35’ to 78^{o} 45’ E Longitude and 17^{o} 47’ to 17^{o} 54’ 00” N Latitude and covers an areal extent of 84 sq. km. The study area is situated 60 km north of Hyderabad, Andhra Pradesh, India. It is covered by Archaean granite exposed to deep weathering processes that form two main aquifer layers, i.e., the saprolite and underlying fissured layers followed by hard bedrock. Saprolite is the major part of the aquifer system, which is responsible for the maximum holding capacity of water storage together with a part of fissured zone with fretted density of fractures. Delineating this combined zone in hard rock is of utmost importances, which are not very precisely detected by the surface geophysical methods.

As we know soils and rocks are composed mostly of silicate minerals which are essentially insulators. Therefore, conduction is largely electrolytic and thus the resistivity depends mainly upon: rock type, porosity, nature of the water/fluid, hydraulic permeability, moisture content, concentration of dissolved electrolytes, temperature and phase of pore fluid, amount and composition of colloids e.g., clay content and metallic content of the solid matrix.

Resistivity logs by directly energizing the geological formation through borewells were obtained and on quantitative interpretation were found effective in delineating the thicknesses of the saprolite which ranges from 10 m to 35 m in the studied watershed. The bedrock depth varies from 28 m to 60 m and is found to more or less follow the topographic surface. Based on the resistivity variations obtained from logs, where the effect of temperature was insignificant for the studied borewells, porosity logs was calculated for each borewell, which gives us the amount of water storage around a particular borewell. Porosity was then integrated between the limits of saprolite to estimate the water content in the saprolite zone in each borewell assuming its saturation and latter taking the global average, the water reserve was calculated. The average stored water in saprolite was found to be 3.34 m^3/m^2 and the total stored water in saprolite in the watershed is estimated to be 26.7×10^7 m^3. Taking into account the average annual rainfall i.e., about 700 mm in the area it was predicted that the stored water in saprolite is just five times the annual rainfall, which alerts that the available borewells in the area will sustain no longer if they are over-exploited. The present study provides useful informations on production aquifer zone to prepare the precise hydrogeological model of the area which cannot be neglected from Water Resource Management point of view in hard rock regions.

Keywords: Electrical Resistivity Logging, Saprolite layer, Porosity, Water storage, Andhra Pradesh, India