ENERGY POTENTIAL AND GEOCHEMICAL INVESTIGATION OF GEOTHERMAL SPRING TATTAPANI, AZAD JAMMU AND KASHMIR, PAKISTAN

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ABSTRACT

This research employs resistivity and geomagnetic surveys to investigate the subsurface characteristics of the Tattapani geothermal spring located in Kotli, Jammu & Kashmir, Pakistan. The study utilizes a 1D resistivity survey, specifically the Vertical Electrical Sounding technique using Schlumberger electrode configuration. Subsequently, acquired data undergo processing with iterative software to derive resistivity values for distinct subsurface layers, revealing their lithological composition. The resistivity structure of the spring reveals four distinguishable lithology units characterized by their resistivity contrasts. The high resistivity unit (300 ohm meters) corresponds to weathered dolomite/limestone of the Abbottabad Formation. The low to moderate resistivity unit (80ohm meters–200 ohm meters) comprises clay and sandstone layers from the Patala Formation, indicating the presence of potential surface meteoric water. The low resistivity unit (20 ohm meters – 80 ohm meters) is associated with moderately altered hydrothermally modified rocks, while the lowest resistivity unit (05ohm meters –20 ohm meters) delineates the geothermal spring with a high dissolved mineral content. The thermal spring is situated on the right bank of the River Poonch, at a depth of 30 meters below the surface, extending deeper in the North-East direction. In addition to the resistivity survey, a magnetic survey was conducted to illustrate deep-seated tectonics, magnetic properties of the rock, and the depth of the hot spring, aligning with the resistivity data. The magnetic intensity and anomaly exhibited abrupt and gradual changes, with an intensity variation of 460nT and an anomaly ranging from -75nT to 60nT, indicating a fault in the sedimentary sequence. The magnetic data aligns with the geological and resistivity data, revealing two distinct magnetic signatures associated with the Patala Formation and the anticlinal Abbottabad Formation.To summarize, the results indicate that the resistivity structure of the Tattapani geothermal spring is concentrated at the interface of low-resistivity rock from the Patala Formation above and weathered and altered high-resistivity rocks

from the Abbottabad Formation below. Furthermore, a comprehensive magnetic survey highlights the tectonic features and geological characteristics associated with the spring's thermal source. The study underscores the geothermal potential of Tattapani for power generation, based on its favorable tectonic setting, accessibility, and deeper heat source. Nevertheless, further investigations such as gravity, geotechnical, and geochemical analyses are recommended to assess its feasibility.

The primary objective of this research is to comprehensively characterize, identify, and evaluate the Tattapani thermal spring, taking into account its mixing patterns, contamination susceptibility, and weathering characteristics. These aspects are crucial as they may impact the water quality in the surrounding community. The study employs both 2D and 3D resistivity surveys to outline underground aquifers, thermal plumes, and thermal springs, allowing for the discernment of mixing patterns and potential contamination based on variations in resistivity. The resistivity characteristics in the study area range from ≥05Ωm to >500Ωm, with different geological units exhibiting distinct resistivity signatures. Two freshwater aquifers are identified, separated by an impermeable layer of shaley clay, with depths varying from >10 meters to ≤20 meters and >50 meters, respectively. The thermal spring is located at a depth range of >40 meters. The mixing of thermal and freshwater occurs within the depth interval of 40 meters to 80 meters, affecting the ionic chemistry of the water at the surface. Geochemical analysis of Tattapani thermal water involves collecting samples from the spring and nearby boreholes to assess contamination and mixing, as well as to determine the thermal water's source and apply geothermometry techniques. The analysis reveals that Tattapani thermal water exhibits characteristics of an immature HCO3 mixed type with elevated Mg levels, consistent with thermal and freshwater mixing. Isotopic analysis (18O, 2H, and 3H) confirms the meteoric origin of the thermal water, indicating a short residence time. However, determining subsurface temperatures accurately is challenging due to complex mixing behavior, resulting in varying geothermometer-based estimates. These estimates range from 116°C to 472°C, placing the Tattapani thermal spring within a range of low to high enthalpy regimes.Despite the complexity of the mixing behavior and the presence of heavy metal contamination, particularly chromium (Cr), ranging from 0.25 ppm to 56.52 ppm, the study suggests that Tattapani has potential for geothermal power generation and direct utilization as a heat source. Further investigations, including gravity, geotechnical, and geochemical analyses, are recommended to assess its feasibility in more detail.