

ABSTRACT

Groundwater is a very important natural resource for the sustainable development of a region. It is the only viable source of water in many areas where the development of surface water is not economically viable. Groundwater is found in pore spaces between grains in alluvial and cracks developed due to weathering, fracturing, faulting, fissures, etc. in hard rock areas. The occurrence and movement of groundwater in hard rock terrain are limited by its secondary porosity and largely depend on the extent and depth of weathering/ fractures and interconnection of joints.

The present research work has been carried out in the Singrauli coalfield region situated in central India under Northern Coalfields Ltd, (NCL). The Singrauli coalfield of India is identified as one of the hot spots in the country for producing coal by the opencast mining method. Coal is also known as the "Black Gold" originating from organic matter wood. It is the main source of energy in India and it fulfills approximately 67 percent of the total commercial energy consumed in the country. Madhya Pradesh has a coal reserve of about 8 percent (25,673 million tonnes) of the country. The main coal deposits of Madhya Pradesh lie in Singrauli, Muhpani, Satpura, PENCH Kanhan, and Sohagpur areas. In the Singrauli coalfield, mainly surface mining is performed. Due to this, it has many harmful impacts on the environment. So this raised many environmental challenges in the study area, including soil erosion, dust, noise, and water pollution, which severely impact adjoining biodiversity.

The mining activities may cause changes in aquifer potential, changes in topography, and land disturbance. Impacts of opencast coal mining on groundwater generally

comprise two phenomena occurring simultaneously viz, water contamination and decline in the groundwater level.

The present thesis embodies the results of the development of a 1-D inversion algorithm and integrated use of geological, hydro-geological, remote sensing, and geophysical studies for groundwater study in the Singrauli coalfield region, Madhya Pradesh, India.

The objective of the present study is to develop a 1-D inversion algorithm for Geoelectrical data and delineate the sub-surface, groundwater potential zones in the Singrauli coalfield region, Madhya Pradesh, India using the integrated geophysical methods. Therefore, Electrical Resistivity methods in corroboration with remote sensing and GIS are used for the appraisal of groundwater potential zones and for demarcation of drilling locations for a sustainable supply of groundwater in the Singrauli coalfield region.

Simple Genetic Algorithms (SGAs) is a global optimization technique and is implemented with the help of a developed MATLAB-based program for the inversion of 1-D Geoelectrical data for Schlumberger electrode configuration to obtain layers parameters (true resistivity and thickness). This program can be used for any optimization problem by changing the response calculations. In this work, the forward response for Schlumberger electrode configuration is calculated using Ghosh's inverse filter method.

The developed Simple Genetic Algorithm (SGAs) program for the inversion of 1-D Geoelectrical data is applied to synthetic data. The results demonstrate that the program performs effectively for the inversion of 1-D Geoelectrical synthetic data.

The response misfit Relative Root Mean Square Error (RRMSE) ranges from 0.018 to 0.049, which is within the acceptable range.

To validate the further performance of the algorithm, it is applied to the five VES field data taken from the research work of Mandal et al. (2021). This data shows a four layers model and is inverted in the same way as the synthetic data for the four layer model is inverted. The results show that the inverted model very closely matches the research paper model and the response misfit (RRMSE) is within an acceptable range, ranging from 0.031 to 0.078. Hence we find that program effectively inverts 1-D Geoelectrical data.

Further, the developed program was used to interpret the acquired 55 VES data in the study area to obtain layer parameters (true resistivity, thickness). The GA-based computer program was executed multiple times (approximately 4 to 5 times) for each set of VES data to get reliable layer parameters. The true layer resistivity and thickness values of various layers obtained from the inversion of VES data were correlated with the available borehole lithology. Based on this correlation and the experiences of local field hydrogeologists, the lithology and water-bearing formations were identified.

The Hydro-geomorphologic and morphometric analysis was carried out using geospatial techniques (Remote Sensing and GIS Techniques) to evaluate different valuable parameters that could help in planning, further detailed exploration, and management of groundwater resources of the study area.

The survey of India toposheets 63L/12 and 63L/16 with a scale of 1:50,000 are used as a source of ancillary information. To generate slope and shaded relief maps, the

Shuttle Radar Topography Mission (SRTM) digital elevation model (DEM) is utilized. Geographic Information System (GIS) and Image Processing software such as ARC VIEW, ARC GIS, and ERDAS IMAGINE are employed for the analysis and mapping of the various layers.

The features namely; geomorphologic unit, slope, drainage, and lineament (surface lineament) that influence groundwater occurrence were extracted from satellite imagery on 1:50,000 scales of the study area.

Groundwater level fluctuation was evaluated in the study area through selective wells for the year 2021. To accomplish this objective, 100 dug wells have been selected around the Singrauli coalfields region for monitoring groundwater level data. The Spatio-temporal distribution of depth to the groundwater level during pre-monsoon, monsoon and post-monsoon for the year 2021 is prepared using ArcGIS software version 10.4. Thematic maps were prepared to represent the key parameters that significantly influence groundwater level fluctuations, including geology, drainage patterns, slope, and elevation. These maps were created using digital elevation models and Survey of India Toposheets within a GIS framework. The collected groundwater level data was then analyzed in combination with these maps to gain insights into the overall groundwater level conditions in the study area.

Based on prior information obtained from remote sensing and GIS techniques, resistivity investigations are carried out in the area. A total of 55 Vertical Electrical Soundings (VES) using Schlumberger configuration are conducted in the Singrauli coalfield region. The potential electrode spacing (MN) varies from 1 m to 40 m and current electrode spacing (AB) is taken between 3 m to 400 m. In the present study,

the field curves have been interpreted in two steps: In the first step, the sounding curves are analyzed indirectly by curve matching techniques using three-layer master curves of Rijkswaterstaat (1969); and corresponding auxiliary point charts. In the second step, the data were interpreted with the help of a developed MATLAB-based program using a Genetic Algorithm. This work aims to evaluate the geohydrological layers and groundwater potential zones' using Geoelectrical sounding data.

The interpretation of VES data and borehole reveals the seven geohydrological formations in the study area, such as topsoil/surface soil (3-953 ohm-m), clay (<20 ohm-m), sand (21-100 ohm-m), highly weathered to semi-weathered sandstone (2-120 ohm-m), less compact sandstone(43-350 ohm-m), compact sandstone (351-1200 ohm-m), and hard rock (>1200 ohm-m). These layer parameters are used to generate the five Geoelectrical cross-sections, which represent the possible geological formations of the study area.

The interpreted layer parameters are used to evaluate the secondary parameters called Dar-Zarrouk parameter for the characterization of the aquifers. Dar-Zarrouk parameters are used to generate different maps: longitudinal conductance map, transverse resistance map, depth to resistive sub-stratum map, and coefficient of anisotropy map. The protective capacity of the aquifer is evaluated from the longitudinal conductance, and it is inferred that the aquifers in the area have moderate to good aquifer protective capacity and hence have optimum protective capacity for maintaining the freshwater aquifer in the area.

Abstract

The study evaluates the groundwater potential zones in the area and identifies suitable locations for the drilling of productive tube wells/dug wells for a sustainable supply of water in the study area.

The integrated geophysical study in the area has proved to be quite successful in mapping the sub-surface geological features. The presence of semi-weathered/semi-fractured to highly weathered/fractured zones are the key components of the aquifer system in hard rock areas and form the most promising zones of groundwater in the study area. The results of electrical resistivity and borehole lithology reveal the presence of semi-weathered or highly weathered zones in the area that could act as a conduit for the flow of groundwater. Thus it is observed that integrated geophysical study is very helpful in identifying hydrogeological and hydrological knowledge of study area.

