Abstract

Surface geophysical and remote sensing techniques are widely used for the exploration of ground water in any geological setup. Geophysical methods can efficiently delineate subsurface formations including the thickness and lateral extent of water bearing lithounits, thus providing better estimation of ground water potential of an area. Remote sensing technique, on the other hand, can identify surficial features having a direct control on the ground water occurrence and movement, thereby measuring the ground water potential of the area indirectly. In soft rock areas aquifers are generally unconsolidated sediments where the ground water availability is mainly controlled by primary porosity of the formation. In many cases the aquifers are clastic sediments with grain size varying from clay to coarse sand and gravel. The hydrogeological parameters also vary considerably from one lithounit to the other and within the same unit. As a result, siting of successful wells cannot be done based solely on remote sensing data. Additional investigations, such as drilling and geophysical surveys, are necessary for a complete understanding of ground water systems. However, detailed geophysical surveys over large areas are very expensive and time consuming. Therefore, a maximum use of remote sensing data and existing maps is crucial in the identification of target areas for detailed investigation. The primary objective of this study is to develop an optimal integrated remote sensing and geophysical approach for the ground water resource potential modelling in a soft rock area. A 535 km^2 area in Midnapur District, West Bengal, India (22°15′ N, 87°10′ E to 22°27′30″ N, 87°22′30″ E), which have a long and varied history of adequate water supply problem, is selected for the proposed analysis.

Indian Remote Sensing (IRS-1B) LISS-II imagery, aerial photographs and topographic maps are used for mapping the geology, geomorphology, soil, drainage density, slope and surface water bodies of the study area (535 km^2). These data are integrated logically through GIS by assigning numerical weights to the maps and ratings to the features of each map by adopting Saaty's Analytical Hierarchical Process (AHP). Subsequently, a detailed geophysical investigation using seismic refraction and DC resistivity methods are conducted in a 226 km^2 region of the study area for the delineation of actual ground water condition.

Inversion of seismic and geoelectric data sets separately may lead to incorrect parameter estimation especially in complicated geological setup. Stability and non-uniqueness can be reduced to a great extent by integrating physically different sets of data into a joint or sequential inversion scheme. One such joint application algorithm, multi-sequential in approach, is proposed in this study to invert resistivity data guided by seismic velocity-depth section. The proposed sequential inversion algorithm is coded in Visual C++ in Microsoft Windows '95 environment to develop a graphical interactive and menu driven user friendly package for the systematic analysis of all the 156 VES curves of the benchmark area (226 km^2). The results are validated by available borehole geophysical logs (point resistance and SP) and the corresponding lithologs.

The subsurface parameters viz. electrical resistivity and thickness of the aquifer, resistivity and thickness of the overburden obtained through sequential inversion at different survey points are contoured by Krigging and the corresponding thematic maps are prepared. These maps along with the physiographical maps of soil, slope, and net recharge are integrated using the same Hierarchical Process adopted for the integration of remote sensing data. Semi-empirical relations worked out between the aquifer parameters derived from sequential inversion of seismic and VES data and hydraulic parameters estimated from pumping test are used for the assignment of ranks to different aquifer parameters (resistivity and thickness). GWPI map thus obtained yields an accurate model of the ground water system of the area in good agreement with the corresponding 226 km^2 GWPI map obtained from remote sensing and topographic data. GWPI map generated from surface geophysical data is used to calibrate the hydrogeological GWPI model of the benchmark area (226 km^2) for the full spatial coverage of the survey district (535 km^2).

The study reveals that the GIS integration of multiple data sets derived from remote sensing and topographic data, with various indications of ground water availability, can be used as a reconnaissance tool in demarcating ground water potential in a soft rock area for detailed surface and subsurface geophysical investigations. The joint application scheme for the sequential inversion of seismic refraction and vertical electrical sounding data can be used effectively in delineating shallow aquifers even in complex geological setup. Ground water exploration of a large area using geophysical tools is expensive and time consuming. Therefore, a conjunctive use of remote sensing and geophysical data enables in ground water potential modelling cost effectively.

Key words : Ground water, remote sensing, GIS, thematic map, numerical weights, feature ranking, Saaty's analytical hierarchical process, ground water potential index (GWPI), seismic refraction, ray inversion for near surface estimation (RINSE), vertical electrical sounding (VES), evolutionary programming (EP), ridge regression, singular value decomposition (SVD), sequential inversion, equivalence, suppression, layer parameters, aquifers, pseudo-section, quasi-2D geoelectric section, borehole lithologs, geophysical logs, seismo-electric panel diagram, pumping test, hydrogeological parameters.