ABSTRACT

Groundwater lowering and aquifer depletion due to over-exploitation and increasing pollution worldwide are threatening our ecosystems and even the life of our future generations. India is no exception and the overuse of groundwater is reported from different parts of the country. Particularly, West Medinipur district of West Bengal in eastern India is suffering from growing water shortages because of increasing water demand and erratic monsoon. Consequently, groundwater is an inevitable water supply source in the district. However, excessive pumping of groundwater is causing lowering of groundwater levels in some parts of the district. Thus, the severe water shortages in West Medinipur district threaten sustainable agricultural production as well as the health and sanitation of the inhabitants. Unfortunately, no scientific studies on water management have been conducted to date in this district. Therefore, the present study was carried out selecting West Medinipur district as a study area. It deals with the hydrologic and hydrogeologic analyses of the study area, identification of groundwater potential zones in West Medinipur district using integrated remote sensing (RS) and GIS techniques, investigation of stratigraphy in Salboni Block of West Medinipur district by the surface resistivity method and identification of recharge zones and suitable sites for artificial groundwater recharge in the district using RS and GIS techniques.

Seven years (1997-2003) monthly rainfall data from eight rainguage stations over the study area were used to analyze the spatio-temporal variations of rainfall. Fourteen years (1990-2003) pre- and post-monsoon groundwater-level data were analyzed to assess groundwater characteristics in the study area. Seven lithologic profiles, 14-year (1990-2003) groundwater-level data and groundwater quality parameters for both dry and wet seasons for the period 1993 to 2003 of Salboni Block were also analyzed to examine the stratigraphy, groundwater characteristics and suitability of groundwater for drinking and irrigation purposes in the area. Seven thematic maps namely geomorphology, geology, soil, slope, drainage density, recharge and surface water body were used to prepare a groundwater potential map of the area. Different themes and their individual features were assigned weights using Saaty's analytical hierarchy approach. These different thematic layers were then integrated using ArcInfo software to prepare a groundwater potential map. Vertical electrical sounding (VES) surveys were conducted at 38 locations in Salboni Block of West Medinipur district to explore the stratigraphy and aquifer systems. A genetic algorithm (GA)-based stand-alone computer code in 'C' programming language was developed to optimize subsurface layer parameters (i.e., true

resistivity and thickness of subsurface layers) from the VES data. Thereafter, the thematic layers on aquifer resistivity and thickness were delineated from interpretation of the VES data. A groundwater potential map of Salboni Block was prepared by integrating the thematic layers on aquifer resistivity, aquifer thickness, geology and soil, which was used to validate the RS- and GIS-based groundwater potential map. An artificial recharge zone map of West Medinipur district was also prepared using the thematic layers on geology, geomorphology, drainage density, slope and aquifer transmissivity. Finally, considering the lineaments map and the 2^{nd} and 3^{rd} order streams maps, suitable sites for artificial recharge were identified.

The statistical analysis of rainfall revealed that although there is a significant spatial variation of rainfall in the study area, the temporal variation of rainfall is statistically insignificant. The analysis of the pre- and post-monsoon groundwater-level data revealed that the mean pre-monsoon groundwater depth generally varies from 1 to 15 m from the ground surface with a major portion of the area having 6 to 9 m groundwater depth, whereas the mean post-monsoon groundwater depth varies from 1 to 11 m with major part of the area having mean post-monsoon groundwater depth of 3 to 6 m. Furthermore, a major portion of the study area has a mean groundwater fluctuation of 2 to 4 m, which gradually increases from 4 to 10 m towards the eastern part of the study area. The stratigraphy analysis of Salboni Block revealed that the main aquifers (confined ones) are available at relatively deeper depths ranging from 60 to 120 m with an average thickness of 20 m. The groundwater of the block was found to be suitable for both drinking and irrigation purposes according to the standard guidelines. Based on the groundwater availability, the study area was divided into three distinct groundwater potential zones viz., 'good', 'moderate' and 'poor' with a major portion of the area falling under 'moderate' zone. In the 'good' zone, the average annually exploitable groundwater reserve was estimated to be 401 MCM (0.29 MCM/km^2), whereas it is 1334 MCM (0.25 MCM/km^2) for the moderate zone and 397 MCM (0.13 MCM/km^2) for the 'poor' zone. The interpretation of the apparent resistivity data with the help of GA-based computer program revealed that the resistivity of the unsaturated zone generally varies in the range of 25-400 Ω-m in Salboni Block. The presence of groundwater in the area is indicated by the resistivity in the range of 30-65 Ω-m and the thickness of aquifers generally varies from 4 to 30 m. A comparison of the groundwater potential map obtained by the geoelectrical method with that obtained by RS and GIS techniques indicated that the RS and GIS techniques successfully identified groundwater potential zones in Salboni Block. Groundwater potential zones were also found to be in agreement with the results obtained from the analysis of available well logs.

The artificial recharge map prepared by remote sensing and GIS techniques divide the area into three distinct groundwater recharge zones viz., 'suitable', 'moderately suitable' and 'not suitable', and finally 40 favorable sites for artificial recharge were identified. As the favorable recharge sites are located in the streams, check dams are mainly suggested as artificial recharge structures, which can intercept the streamflow and thereby enhance groundwater recharge. Other recharge structures such as percolation ponds and on-farm reservoirs can also be constructed on moderate slopes in the demarcated favorable zones. Overall, it is concluded that RS and GIS are powerful tools for investigating groundwater and formulating a suitable groundwater development and management plan. Based on the findings of this study, the concerned decision makers can develop groundwater utilization strategies so as to ensure long-term sustainability of this vital resource.

Keywords: *Remote sensing, GIS, Groundwater potential zoning, Saaty's analytical hierarchy process, Vertical electrical sounding (VES), Resistivity inversion, GA, Artificial recharge zoning, Groundwater recharge, Groundwater exploration.*