

## Abstract

The district Dangs marks the extension of Western Ghats in Gujarat state, western India. It is characterized by uniformly spread less transmissible basaltic rocks, rugged trappean highlands and moderate to very steeply sloping surfaces along with highest average annual rainfall of 2000 mm in the state of Gujarat. These critical terrain conditions give rise to higher runoff than infiltration, leading to water crisis during non-rainy period. During this crisis time, the groundwater is the main source of freshwater for the people and thus holds the utmost importance. The occurrence, distribution, recharge and quality of groundwater is dependent on vivid geo-environmental parameters (GEPs) such as geology, drainage, geomorphology, slope, lineaments, soil and land-use. The Khapri watershed cover the maximum area of district Dangs and experiences acute shortage of groundwater as compared to other parts of the district. *Hence, the present study focuses on (i) assessment of geo-environmental parameters for demarcating the groundwater potential zones, (ii) synthesize the status of groundwater quality for drinking as well as irrigation and (iii) understand groundwater recharge pattern in Khapri watershed.*

The thematic maps of GEPs viz., geology, drainage, geomorphology, slope, lineaments, land-use and soil are prepared using the techniques of remote sensing-GIS and available reference data. These thematic maps are subjected to Weighted Overlay Analysis (WOA) in Arc GIS 10.4 to derive the groundwater potential zone map. To reduce the human bias, the weightages for individual GEPs are derived using multi-criteria decision method (Analytical Hierarchical Process) (MCDM-AHP) instead of assigning arbitrary weightage. The MCDM-AHP method simplifies the intricacy of multi-parametric problem to a single hierarchical structure, with judgements regarding the relative importance in the form of pairwise comparison matrix (PCM) of GEPs and its sub-classes. The resultant groundwater potential zone map of the Khapri watershed is then classified into five categories viz. Very good, Good, Moderate, Poor and Very poor. The results indicate the maximum area (154.28 km<sup>2</sup>) of Khapri watershed is occupied by the moderate category of groundwater potential zone, followed by Poor (131.73 km<sup>2</sup>), Good (105.49 km<sup>2</sup>), Very Poor (82.50 km<sup>2</sup>) and Very Good (38.81 km<sup>2</sup>). The correlation of resultant groundwater potential zones with pre-monsoon (2022, 2023) and post-monsoon (2021, 2022) groundwater fluctuation data, yielded 75% dependability of the map.

To determine the suitability of groundwater for drinking and irrigation purposes the physico-chemical parameters (pH, EC, TDS, temperature, total hardness (TH), total

alkalinity (TA), cations (Calcium ( $\text{Ca}^{+2}$ ), Magnesium ( $\text{Mg}^{+2}$ ), Sodium ( $\text{Na}^{+}$ ) and Potassium ( $\text{K}^{+}$ )), anions (Nitrate ( $\text{NO}_3^-$ ), Sulphate ( $\text{SO}_4^{2-}$ ), Chloride ( $\text{Cl}^-$ ) and Bicarbonate ( $\text{HCO}_3^-$ )) and irrigation water quality parameters (SAR, RSC and Kelly's ratio) are evaluated respectively. To understand the dominant mechanism governing the groundwater chemistry, Gibbs, 1970 diagram is used. The analytical results of pH indicate neutral to weakly alkaline, EC indicate low conductive and TDS indicate fresh nature of groundwater in Khapri watershed. The chemical analysis of groundwater suggests, the calcium and magnesium are the dominant cations followed by sodium and potassium. Among anions, the bicarbonate is dominant followed by chloride > sulphate > nitrate. The higher values of bicarbonate may attribute to silicate weathering of the basalt. The comparison of the cations and anions in the groundwater with BIS (2012) standards indicate that the water is suitable for drinking. The values of irrigation water quality parameters such as SAR (0.02-0.4), RSC (-1.21 to 2.12) and Kelly's ratio (0.11 to 0.19) indicate the groundwater is suitable for irrigation purposes. The Piper trilinear diagram indicates the  $\text{Ca-HCO}_3^-$  type chemical character of groundwater. The Gibbs diagram reflects rock weathering is the dominant mechanism governing the groundwater chemistry.

To decipher the groundwater recharge patterns in the Khapri watershed, the stable isotope analysis ( $\delta^{18}\text{O}$  and  $\delta^2\text{H}$ ) of rainwater, river water and groundwater is carried out through Isotope Ratio Mass Spectrometry (IRMS) at PRL, Ahmedabad. The stable isotope study highlights four groundwater recharge patterns through different sources viz. (i) Meteoric water which directly infiltrates through negative lineaments that act as a conduit for recharging the shallow groundwater aquifers (ii) Rivers and reservoirs recharge the shallow groundwater aquifers through water percolation (iii) Springs which are recharging the surrounding wells throughout the year and (iv) Deeper groundwater from the borewells and hand-pumps used for agriculture, constitutes the return flow for recharging the shallow groundwater aquifers.

For the groundwater resource sustainability in the Khapri watershed various effective recharging structures have been proposed at suitable locations by considering, the groundwater potential zones, groundwater quality and recharge patterns.