

Groundwater is an important commodity in Saudi Arabia. Groundwater is an important commodity in Saudi Arabia. Overall, this study justifies that continuous monitoring and management are required in this aquifer to maintain safe water quality and sustainable aquifer management in the study site.  $\text{NO}_3^-$  is mostly derived from anthropogenic sources (agriculture return flow, fertilizers, manures, domestic wastewater, pit lateen and septic tank leakage) while fluoride is derived from geogenic sources (fluoride minerals dissolution) in the study site. Contamination zone mapping (CZM) reveals that most of the parameters behave similarly and the groundwater is unsuitable in most of the territory except a few pockets in the southern and northern regions where groundwater is moderately suitable. In the case of  $\text{HCO}_3^-$ , higher values are identified in the middle and upstream regions due to geogenic sources and lower values are observed downstream due to evaporation and carbonate precipitation. Likewise, SAR (58%), KR (77%),  $\text{Na}^+$  (34% good; 60% permissible), PI (8% good, 92% suitable) and MH (81%) are recommended for irrigation applications. Similarly, low sodium water (S1) is suitable for majority crops and plants whereas medium sodium water (S2) is suitable only for coarse-textured soil. The EC is generally 5000  $\mu\text{S}/\text{cm}$  in 68% of samples and elevated values are inferred in the coastal region, which seems to be due to evaporation and evaporite dissolution. The examination of drinking water appropriateness suggests that more than 90% of samples surpassed the recommended limit provided by national (SASO) and international (WHO) organisations and were not recommended for oral consumption. For example, Check dams and surface storage structures are important options to enhance the aquifer recharge and, consequently, reduce the salinity and other ions in the groundwater. Thus, groundwater quality evaluation along with contamination zone mapping was performed in the Kulais region, KSA. There is a large variation in water quality, inferred from EC, TDS and TH, in this aquifer and the water quality is controlled by multiple processes and sources in the study site. The water is neutral to slightly alkaline.  $\text{NO}_3^-$  is mostly derived from anthropogenic sources (agriculture return flow, fertilizers, manures, domestic wastewater, pit lateen and septic tank leakage) while fluoride is derived from geogenic sources (fluoride minerals dissolution) in the study site. In the case of  $\text{HCO}_3^-$ , higher values are identified in the middle and upstream regions due to geogenic sources and lower values are observed downstream due to evaporation and carbonate precipitation. In the study region, the major water type is Ca-Mg-Cl (75%) followed by Na-Cl.