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HYDROGEOLOGICAL ASSESSMENT OF GROUNDWATER IN THE METAMORPHIC TERRAIN OF DRY ZONE, SRI LANKA: INTEGRATION OF PIPER CLASSIFICATION, MULTIVARIATE ANALYSIS, AND GEOLOGICAL MAPPING

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Interactions between rocks and water in a metamorphic terrain play a crucial role in shaping the chemical evolution of groundwater geochemistry. Precise determination of the geochemical signatures of groundwater can offer a rapid method for geological mapping programs, leading to significant cost savings by avoiding the need for expensive drilling. The Piper trilinear diagram is commonly employed for hydrogeochemical facies determination. However, the Piper method relies only on the geochemistry of main ions, and categorizes water types into limited groups, restricting the identification of fine structures within groundwater signatures. In this investigation, the Piper method was employed to ascertain the hydrochemical composition of groundwater, predicated on the mineralogical characteristics imparted by the lithological formations within the aquifer systems in Netiyagama located in Anuradhapura District. The variation of major ions concerning rock types was used to identify different patterns based on lithology. The resulting sub-groups were further classified using a multivariate statistical method. Total alkalinity (30.38-601.72 mg L^{-1} $CaCO_3$), pH (6.49-8.57 mg L^{-1}), TDS (75-1035 mg L^{-1}) and EC (155-1850 mg L^{-1}) were determined for each unfiltered sample within 24 h of collection. Anions and cations in samples were determined through ion chromatography and inductively coupled plasma optical emission spectroscopy, respectively. Results show that the major ions and their variations are as, Ca^{2+} (6.67-195.38 mg L^{-1}), Na^+ (14.09-317.22 mg L^{-1}), K^+ (0.64-26.14 mg L^{-1}), Mg^{2+} (2.89-96.02 mg L^{-1}), SO_4^{2-} (4.98-193.58 mg L^{-1}), Cl^- (10.85-668.23 mg L^{-1}), HCO_3^- (37.06-734.09 mg L^{-1}) and CO_3^{2-} (75.26-1490.80 mg L^{-1}). Water classification and hydrogeochemical mapping were done using Origin Pro software and ArcGIS mapping software, respectively. Piper analysis classified water facies as Ca-HCO_3, Ca-Cl, Na-K-HCO_3, Ca-Mg-Cl, and Na-Cl. The predominant water type, $CaHCO_3$, encompasses over 85% of shallow and deep well water, with a minority comprising Ca-Cl, Na-K-HCO_3, Ca-Mg-Cl, and Na-Cl. Surface water in discharge areas predominantly falls into the Na-K-HCO_3 type, with occasional occurrences of Na-Cl. The geology of the area comprises granitic gneiss, biotite gneiss, and hornblende biotite gneiss. Recharged areas exhibit heightened weathering of granites and amphiboles, supplying elevated levels of Ca^{2+}, Na^+, Cl^-, F^- and Sr to the water. Element depletion and enrichment are linked to leaching of primary mafic minerals of hornblende, biotite, plagioclase due to prolonged residence time. Hydrogeochemical components and clusters identified through HCA analysis unveil subsets within the data that exhibit notable enrichments of bicarbonate (HCO_3^-), sodium (Na^+), and fluoride (F^-) ions, especially within deep groundwater sources.

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