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Hydrochemical evaluation of groundwater evolution within the lower Pra Basin, Ghana: A hierarchical cluster analysis (HCA) approach

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Abstract

The most relevant controls on groundwater quality within the Lower Pra Basin in South-Western Ghana were assessed using Q-mode hierarchical cluster analysis (HCA). The pattern recognition technique of HCA was employed to characterize hydrochemical data from a total of sixty-eight (68) boreholes and two (2) streams within the Lower Pra Basin into water groups and subgroups. A spatial plot of the water groups and subgroups consisting of samples from the basin showed that, majority of samples in the same group are located in close proximity to one another suggesting that, the same hydrogeochemical processes and /or flow path are taking place within the aquifer with which the waters are in contact. The high degree of spatial and statistical coherence suggests that, the changes between the principal hydrochemical facies define the hydrochemical evolution of groundwater within the basin. The sequence of the abundance of the major ions is in the order: $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ and $HCO_3^- > Cl^- > SO_4^{2-}$. Hydrochemical facies using Piper trilinear plot delineated two main water types –the Na-HCO_3 and Ca-HCO_3 with Na-Cl, Na-SO_4 and Ca-Mg-Cl as minor water types. Water quality data for subgroups were assessed using Chadha diagram to understand the chemical differences between the subgroups and geochemical changes along the groundwater flow path. The results showed that, the water groups and subgroups represents transition zones between Ca-Mg-HCO_3/Na-HCO_3 and Na-Cl/ Ca-Mg-Cl /Na-SO_4 water types and therefore, can be regarded as transition zone between naturally circulating ground waters which have not undergone pronounced water-rock interaction and saline and /or permanent hard water, suggesting that, groundwater within the basin perhaps, evolves from a fresh- Ca-HCO_3 type water to Na-HCO_3 type water to permanent hard- Ca-Mg-Cl type water to brackish/saline- Na-Cl type water along the flow path.

Biography

Collins Tay is currently a Ph.D. student at the University of Ghana, Legon and a Senior Research Scientist has been with the Council for Scientific and Industrial Research-Water Research Institute (CSIR-WRI) since 2001. He has been working at the Environmental Chemistry Division. Born in Accra in 1969, he attended the Kwame Nkrumah University of Science and Technology (KNUST) and holds a Bachelor of Science (B.Sc.) degree in Chemistry and a Master of Science (M.S) degree in Environmental Resources Management. He is a member of the Ghana Science Association, Research Staff Association of CSIR and currently, the National Vice President. His primary research interests are in the monitoring of organic pollutants (Pesticides, PAHs, PCBs and TPH) in industrial, urban and agricultural wastewaters/environmental samples, monitoring of heavy/trace metal pollution in water resources/environmental samples and water quality assessment and monitoring. Mr. Collins Tay has seventeen (17) scientific publications both in local and international Journals in the areas listed in his research interests. He is currently a reviewer of scientific articles submitted to the West African Journal of Applied Ecology (WAJAE) and Journal of Ecology and Natural Environment (JENE).