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APPLICATION OF PRINCIPAL COMPONENT ANALYSIS IN THE CONTEXT OF MULTIVARIATE STATISTICS AND ITS USE FOR HYDROGEOCHEMICAL ANALYSIS

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Abstract

The overexploitation of groundwater due to increasing irrigation, domestic demands, and industry has led to the degradation of groundwater resources worldwide. Therefore, rigorous statistical techniques are required to simplify groundwater evaluation and monitoring. In this paper, we consider the application of Principal Component Analysis (PCA) to identify sources of ions in groundwater. Two data sets were derived from the Western Sokoto Basin, comprising hydrochemical data from shallow and deep aquifers. We show how PCA can be applied to identify sources of ions. Along with Hierarchical Cluster Analysis, PCA enables groundwater classification based on the mechanisms controlling the hydrochemistry of groundwater. The exploratory PCA and associated PCs and Biplots offer insights that can provide water quality analysts with an understanding of the experiential water composition influenced by natural and anthropogenic processes. PCA offers a comprehensive, straightforward, and cost-effective tool for standard and innovative analysis that helps water quality analysts discover, recognize, and analyze the accumulating volumes of water quality data by reducing data and retaining the major components characterizing the hydrochemistry of aquifers or surface water. Therefore, this study provides the basis for PCA application in groundwater quality analysis and monitoring for pollutant source identification, especially in data-poor regions where historical data is lacking. Theoretically, this review further enriches the literature on the systematic approach to assessing groundwater quality analysis, monitoring, and management using PCA. Practically, PCA is a robust statistical tool for identifying complex relationships between different physicochemical parameters and their links to natural and human processes. This review presents a new approach to hydrogeochemical analysis different from the conventional PCA application in the existing literature, which concerns hydrochemical data reduction. Thus, the PCA model used in this study can be used by environmental agencies seeking long-lasting and cost-effective improvement of their water quality assessment and monitoring.

Keywords: exploratory PCA, hierarchical clustering analysis, pattern identification, principle of PCA, PCA scores and loading plots

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