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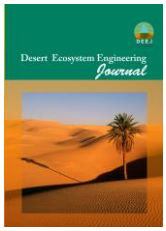

Modelling of sodium absorption ratio (SAR) using some of the Artificial Intelligent Models (AIM) (Case study: Some of the hydrometric stations of Kashkan watershed)

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Extended Abstract

Introduction: Water quality plays a crucial role in the optimal management of water resources, directly impacting both public health and the environment. Water finds its application across various sectors, including agriculture, drinking water supply, and industry. Among the diverse sources of water, rivers have been historically favored for the development of human societies due to their accessibility. Within river systems, the Sodium Adsorption Ratio (SAR) stands out as a key water quality parameter used to assess the suitability of water for both drinking and agricultural purposes. The ratio of sodium ions to calcium and magnesium ions serves as a predictor of the extent to which irrigation water tends to engage in cation-exchange reactions within the soil. This ratio, termed SAR (SAR=), is instrumental in determining the sodium hazard associated with irrigation waters. Given the significant role of the Sodium Adsorption Ratio (SAR) in soil management and stability, its accurate estimation holds particular importance. The purpose of this study was to model the Sodium Adsorption Ratio (SAR) using selected Artificial Intelligent Models (AIM).

Materials and methods: The study area encompasses a portion of the Karkheh watershed, situated in the central Zagros Mountains within Lorestan province, Iran. 1 This watershed was selected as an appropriate case study for evaluating Sodium Absorption Ratio Modeling (SARM). Geographically, the study area lies between 47°12′30″ to 48°59′20″ East longitudes and 33°05′45″ to 34°03′26″ North latitudes, covering an approximate area of 8844.6 km². The watershed's elevation ranges from 760 to 3646 meters above sea level. This region is classified as semi-arid, with mean annual rainfall varying according to topography and location, exhibiting a significant spatial variation from 401 mm in the lower valley to 473 mm in the upper watershed. Consequently, this study compared the performance of three soft computing techniques—Artificial Neural Network-Multi Layer Perceptron (ANN-MLP), Linear Regression (LR), and Random Forest (RF)—to estimate the Sodium Absorption Ratio (SAR) at the Chamanjir, Doab Visian, Cholhol Afrineh, Kashkan Afrineh, and Kashkan Poldokhtar hydrometry stations within the Karkheh watershed, Lorestan province, Iran. The dataset comprised observational water quality data (for training and testing) from the Kashkan watershed in Iran, spanning the period from 1968 to 2023. The complete dataset included measurements of Total Dissolved Solids (TDS), Electrical Conductivity (EC), pH, Bicarbonate (HCO-), Chloride (Cl), Sulfate (SO-), Calcium (Ca), Magnesium (Mg), Sodium (Na), and SAR from the five aforementioned hydrometric stations. Of this data, 70% was used to train the models, while the remaining 30% was used for model testing. Finally, the accuracy of the models was evaluated using three performance metrics: Correlation Coefficient (C.C.), Maximum Absolute Error (MAE), and Root Mean Square Error (RMSE).

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Result: The findings of this study indicate that the Artificial Neural Network-Multi Layer Perceptron (ANN-MLP) model demonstrates superior accuracy in estimating the Sodium Absorption Ratio (SAR) compared to the Random Forest (RF) and Linear Regression (LR) models for the specified study area. Specifically, the test results for the MLP model revealed the following performance metrics: at the Chamanjir station, the Correlation Coefficient (C.C.) was 0.99, the Maximum Absolute Error (MAE) was 0.03, and the Root Mean Square Error (RMSE) was 0.05; at the Cholhol Afrineh station, these values were 0.93, 0.09, and 0.18, respectively; for the Doab Visian station, the results were 0.99, 0.01, and 0.02; at the Kashkan Afrineh station, they were 0.87, 0.10, and 0.24; and finally, at the Kashkan Poldokhtar station, the values were 0.92, 0.05, and 0.19. Furthermore, sensitivity analysis revealed that Sodium (Na) is the most influential parameter in the estimation/prediction of the Sodium Absorption Ratio (SAR) across all the examined hydrometry stations.

Discussion and Conclusion: The application of soft computing techniques in predicting Water Quality Indices (WQI) can streamline the process and reduce the time involved. In this study, three such techniques—Random Forest (RF), Artificial Neural Network-Multi Layer Perceptron (ANN-MLP), and Linear Regression (LR)—were employed for the prediction of the Sodium Absorption Ratio (SAR) within the Kashkan watershed in Lorestan province, Iran. The results demonstrated that by sampling and measuring various hydro-chemical parameters and subsequently applying soft computing techniques, SAR can be predicted with a high degree of accuracy. Based on the findings of this research, these optimized models offer a viable alternative to the often costly and time-consuming traditional methods of estimating the Sodium Absorption Ratio (SAR) in rivers. Furthermore, these models hold potential for estimating the Sodium Absorption Ratio (SAR) in nearby rivers, even in the absence of hydrometry stations, thereby providing valuable tools for the effective management of surface water quality.

Keywords: Lorestan Province, Kashkan Watershed, Sodium Absorption Ratio (SAR), Modelling, Artificial Intelligent Models (AIM).