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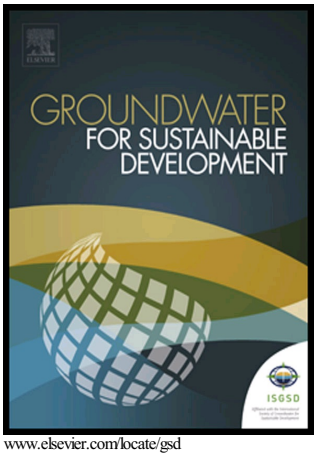

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Evaluation of potential health risk of heavy metals in groundwater using the integration of indicator kriging and multivariate statistical methods

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Abstract

The factors and mechanism which control the spatial patterns of heavy metals in groundwater and their effect on human health could be identified with multivariate statistical methods and human health risk assessment. Sampling wells are statistically classified into two cluster based on the similar characters in groundwater quality using Q-mode cluster analysis (Q-mode CA). Two significant factors were extracted by principal component analyses (PCA), explaining 64.19 % of the total variance. These factors were in turn described by the clusters 1 and 2, respectively, resulting from the R-mode CA. PCA and CA revealed significant anthropogenic contributions and water-rock interaction effects of the metals in groundwater. Health risk assessment factors including chronic daily intake (CDI) and hazard quotient (HQ) indices were computed for child and adult. The HQ indices of Cd and Pb in the both child and adult cases showed the value greater than the safe limits, which cause the harmful health hazards and potential non-carcinogenic health risks to the human. Spatial variability maps using ordinary kriging show that safe zones are mainly covered the west and south-western parts of the study area, while the contamination zones are found to be concentrated in the east, north, and south-eastern parts of the plain. The indicator kriging maps show highly uneven spatial pattern of Pb and Cd concentrations. The probability maps reveal that more than 50% of the total area possessed the highest probability (0.8-1.0) of exceeding the threshold values for Cd and Pb.

Keywords*:* *Groundwater; Heavy metals; Multivariate statistical methods; Indicator kriging; Probability map; Human health risk assessment.*