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Developing a new Bayesian Risk Index for risk evaluation of soil contamination

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Abstract

Soil quality is heavily constrained by industrial and agricultural activities. Potentially Toxic Elements (PTEs) are a threat to public health and the environment alike. In this regard, the identification of areas that require remediation is crucial. In the herein research a geochemical dataset (230 samples) comprising 14 elements (Cu, Pb, Zn, Ag, Ni, Mn, Fe, As, Cd, V, Cr, Ti, Al and S) was gathered throughout eight different zones distinguished by their main activity, namely, recreational, agriculture/livestock and heavy industry in the Avilés Estuary (North of Spain). Then a stratified systematic sampling method was used at short, medium, and long distances from each zone to obtain a representative picture of the total variability of the selected attributes. The information was then combined in four risk classes (Low, Moderate, High, Remediation) following reference values from several sediment quality guidelines (SQGs). A Bayesian analysis, inferred for each zone, allowed the characterization of PTEs correlations, the unsupervised learning network technique proving to be the best fit. Based on the Bayesian network structure obtained, Pb, As and Mn were selected as key contamination parameters. For these 3 elements, the conditional probability obtained was allocated to each observed point, and a simple, direct index (Bayesian Risk Index-BRI) was constructed as a linear rating of the pre-defined risk classes weighted by the previously obtained probability. Finally, the BRI underwent geostatistical modeling. One hundred Sequential Gaussian Simulations (SGS) were computed. The Mean Image and the Standard Deviation maps were obtained, allowing the definition of High/Low risk clusters (Local G clustering) and the computation of spatial uncertainty. High-risk clusters are mainly distributed within the area with the highest altitude (agriculture/livestock) showing an associated low spatial uncertainty, clearly indicating the need for remediation. Atmospheric emissions, mainly derived from the metallurgical industry, contribute to soil contamination by PTEs.

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