Using Indicator Kriging for Lead Spatial Patterns Assessment in sediments- the Caveira Mine Case Study, Portugal

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Background/Objective. Lead pollution (Pb) is widespread in many mining communities around the world, including in developing countries. Anthropogenic contributions of Pb to the environment are primarily associated with fossil fuel emissions and industrial and mining activities. This study, as part of the GeoMaTre project, an ongoing collaborative network (2021-2024) between the Polytechnic Institute of Castelo Branco and the University of Évora, Portugal, aimed to evaluate the potential risk of lead pollution in stream sediments in the surrounding area of Caveira mine. This mine corresponds to one of the decommissioned mining centers of the Iberian Pyrite Belt, a Europe's leading sulfide mining province, in SW Portugal, and includes large mining wastes piles containing significant amounts of metals, mainly Pb, Cu, Zn and Hg. Although the mine and the larger heap are located on a ridge, the regional drainage is not dispersive and all the streams originating from them, converge into the Ribeira de Grândola, used as water supply for agriculture, livestock and domestic uses. Given their spatial arrangement and greater vulnerability, these tailings are the main source of metals of the stream sediments and determine their chemical signature.

Approach/Activities. Thirty-three sediment samples were collected from a depth of 0 to 10 cm, in a square grid of 1Km^2 and preserved at about 4°C. Pb was analyzed by ICP-OES after partial digestion with aqua regia (HCl and HNO_3) in a high-pressure microwave digestion unit. The risk assessment, regarding the proximity of abandoned mineralized deposits, requires a stochastic assessment of the impact of anthropogenic activities. In view of the construction of iso-probability maps, three indicator variables were constructed based on the threshold values of the Portuguese legislation for classifying the quality of dredged sediments according to the contamination degree. The first one (I1), considers the threshold value of the first class (clean material <50mg/Kg), the second one (I2) the third class (slightly contaminated material <150mg/Kg) and the third one, the fifth class (I3) (highly contaminated material <500mg/Kg). Sample omnidirectional variograms were estimated and modeled to quantify the spatial variability of the three indicator variables as a function of their separation distance, followed by Indicator kriging, a non-parametric geostatistical method, for estimating the probability of exceeding the specified threshold values for maps' construction.

Results/Lessons Learned. Using indicator geostatistics, the probability of attribute values in excess of a certain threshold value is mapped. These probability maps are very useful to decision makers because of their easy interpretation and their ability to generate as many maps as the number of the thresholds of interest. The definition of spatial hot-spots of the high probability of exceeding a given threshold provides a faster and more intuitive way to verify whether the previously detected problematic zones are true of concern and in need of mitigation allowing board discussion of the obtained results. The probability of exceeding a specific Pb value makes it possible to identify anomalies with a high probability of lead contamination of sediments and, consequently, a tool for assessing mitigation strategies.