14TH INTERNATIONAL CONFERENCE ON GEOSTATISTICS FOR ENVIRONMENTAL APPLICATIONS

PROCEEDINGS OF geoENV2022

Andrea Zanini & Marco D'Oria, Editors

UNIVERSITÀ DI PARMA

A GEOSTATISTICAL APPROACH FOR MERCURY SPATIAL PATTERNS ASSESSMENT IN SEDIMENTS IN AN OLD MINING REGION -THE CAVEIRA MINE CASE STUDY, PORTUGAL

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Abstract

Mercury pollution is significant in many former mining communities worldwide, including in developing countries. Anthropic contributions to environmental Hg pollution are mostly connected to fuel fossil emissions, industrial and mining activities. Among mining operations, gold exploration contributes to the highest Hg contamination rates, given the processes, widely used in the past, of mixing Hg with the gold-containing ore, to separate this metal from the bulk impurities.

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 mercury pollution in stream sediments in the Caveira area, an abandoned Cu, Pb, Zn, Ag, and Au mine, included in the Iberian Pyrite Belt, at South Portugal. This mine corresponds to a Gossan developed on pyrite mineralization, with high gold and silver content at the official beginning of its exploitation, in 1863, having exhausted the reserves in these precious metals in the 1920s. Until the date of its abandonment (1966) the exploitation focused on the remaining metals (Cu, Pb, Zn) and S. Currently, the surrounding area of Caveira mine is essentially composed of areas of waste accumulation, from mining activity, with little or no vegetation.

Thirty-three sediment samples were collected from within 0 to 10 cm depth, in a grid of 1Km x 1Km. Hg was determined in samples preserved at about 4ºC at the time of collection, through a mercury analyzer (NIC MA-3000) based on thermal decomposition, gold amalgamation, and cold vapor atomic absorption spectroscopy detection.

A multivariate preliminary study was conducted to evaluate the spatial distribution of Hg at the mine area and to determine the spatial clusters of Hg concentration. Analysis showed very high values (50-130$\mu g g^{-1}$), in the sediments deposited in the mainstream crossing the mine heaps, with concentrations reaching 340 $\mu g g^{-1}$ in the meeting with the major waterway of the region. In the latter, near the confluence zone, there is an attenuation of Hg levels, although still above the reference values for sediments, 0.3$\mu g g^{-1}$, according to the Netherlands Regulation (2009), followed by many European countries. Since this is a complex mining area with diffuse distribution of the water system, levels significantly higher than reference values were also found in other small streams in the vicinity of the mine heaps. According to the Hg limits established by this regulation, mitigation measures are required when Hg is greater than 36$\mu g g^{-1}$. Therefore, to identify spatial patterns of the Hg concentration distribution, geostatistical modeling was used throughout conventional variography followed by the Sequential Gaussian Simulation (SGS). The Mean Image of the one hundred performed simulations followed by local G clustering allowed the definition of the significant hotspots for contamination risk. The probability maps of exceeding, respectively, the 0.3$\mu g g^{-1}$and the 36$\mu g g^{-1}$ thresholds

were computed and acted as a measurement of the obtained clusters' robustness, thus providing a faster and more intuitive way to verify whether the previously detected problematic zones are true of concern and in need of mitigation.

Keywords: Caveira mine; Mercury; Sequential Gaussian Simulation; G clustering; Probability map.