Urban arsenic risk assessment, a Portuguese case study

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Abstract

Arsenic is a metalloid commonly associated with sulphide mineralizations and is considered to be toxic in the environment at low levels. The studied abandoned mining area is located at central Portugal and the resulting tailings and rejected materials were deposited and exposed to the air and water since fifty years ago. Sixteen water sample-points were collected during October. One of these was collected outside the mining influence, with the aim of obtaining a reference background. The risk assessment, concerning the proximity to abandoned mineralized deposits, needs the vulnerability evaluation aiming the quantification of the anthropogenic activities. Ordinary Kriging to estimate the arsenic estimated values and Indicator Kriging approach, as a methodology to assess the arsenic probability of exceeding a natural cut-off, were applied. The indicator variable was constructed considering the arsenic water supply standard contamination value (0.05 mg/L) as cut-off value. The probability of being exceeded is, not only directly dependent on the geologic and hydrologic characteristics of the studied area, but also on the anthropogenic activities and can be considered as a vulnerability probability of the studied area.

Keywords: Arsenic; vulnerability; contamination; estimated maps; probability maps

1. INTRODUCTION

Arsenic is a metalloid commonly associated with sulphide mineralizations (e.g., Marszalek and Wasik, 2000; Antunes et al., 2002; Cánovas et al., 2008; Navarro et al., 2008) and is considered to be toxic in the environment at low levels. Although anthropogenic arsenic contamination from mining activities is typically local in extent, contamination can reach levels thousands of times of that from natural (e.g., Smedley and Kinniburgh, 2002).

The extent and degree of arsenic urban risk assessment depends on the mobility and solubility from rejected mining materials to waters.

The main purpose of this study is to make a risk probability mapping for arsenic that would allow better knowledge about the vulnerability of the waters to arsenic contamination.

2. REGIONAL SETTING AND METHODOLOGY

The case study corresponds to an abandoned mining area where the tailings and rejected materials were deposited, since fifty years ago, without significant development. Natural fifteen water sampling points were selected and collected inside mine influence, receiving the drainage from abandoned mines, and one located outside this influence (Fig. 1), to obtain a reference water local geochemical content. The arsenic was determined by Spectrometer Perkin Elmer 303 flame atomic absorption, with a precision of 5% (Antunes et al., 2002).

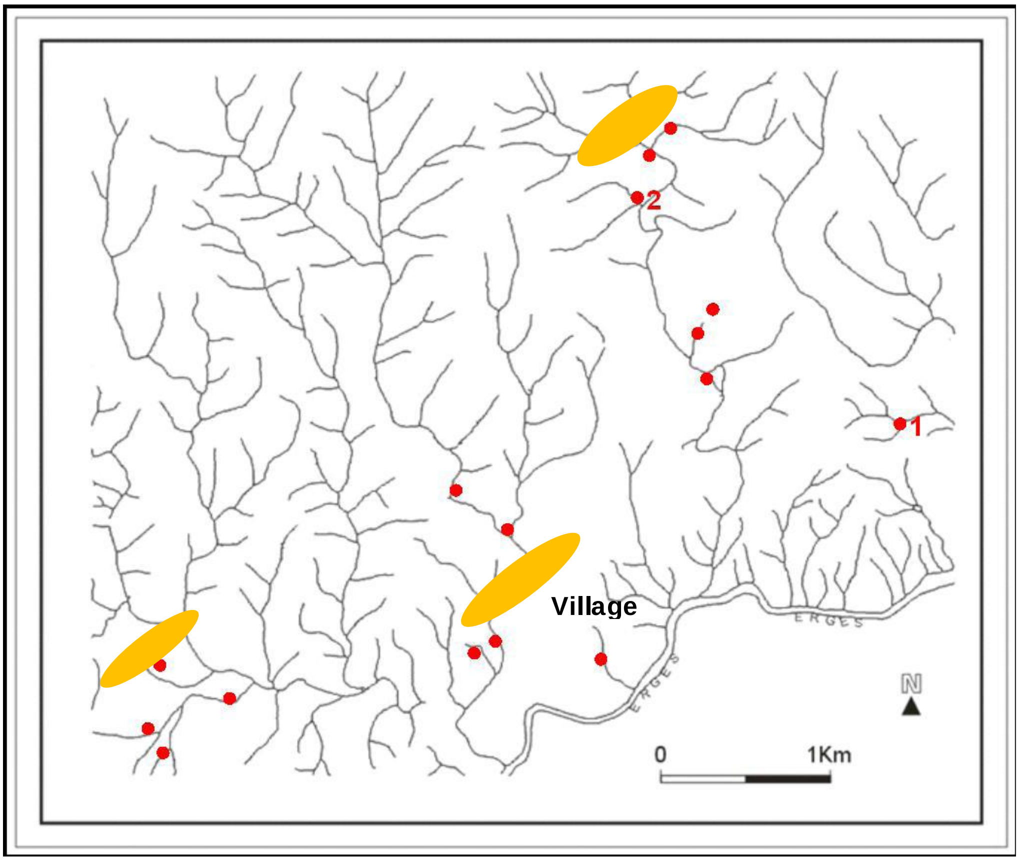

Fig.1. Study area and streams location. Water sample points (red dots): 1 – Background, 2 – Outlier in both studied months; urban area (black dot) and abandoned mining areas (yellow ellipses).

To account for spatial structure, sample variograms were computed for the main directions of the sampling grid and a spherical model was fitted to each sample variogram (arsenic variable and indicator variables). The parameters of the spherical model fitted to the arsenic variable were used to predict arsenic concentrations at unsampled locations. A risk probability mapping was also done to assess the vulnerability of the soil towards the mining works. The parameters of the spherical model fitted to each indicator variable were used to estimate probabilities of exceeding the corresponding threshold. The use of indicator kriging as an alternative to ordinary kriging for the water data produced unbiased probability maps that allowed assessment of the water quality.

3. CONCLUSIONS - ARSENIC RISK ASSESSMENT

The use of indicator geostatistics allows the mapping of probability values of a parameter for more than a certain cutoff value (Goovaerts 1999).

The basic idea of indicator kriging is the variation amplitude discretization of the arsenic concentration data by a set of cutoff values, which in this case study will be 0.05 mg/L (I1) – Portuguese drinking water supply standard). Each original concentration value of arsenic is binary transformed in 1 if exceeds the cutoff value and 0 in the other cases.

The parameters of the spherical models fitted to the arsenic variable and to the indicator variable were used to predict the arsenic concentrations at unsampled locations and an iso-probability mapping that allows the assessment of the water quality (Fig. 2a, b).

The estimated arsenic map shows a strong anomaly occurring in the north of the area corresponding to sampling points receiving water drainage from abandoned mines (Fig. 2c). The iso-Probabilities mapping shows two strong anomalies, also occurring in the north of the area (Fig. 2d). The anomalies indicate that these waters have the highest probabilities for contamination with arsenic and should not be used to human consumption.

The overlaid map (Fig. 2e) shows that one of the highest probabilities for exceeding the arsenic parametric value area is coincident with low estimated arsenic content (Fig. 2e). This area, although showing lower arsenic water contents is a high urban risk zone (Fig. 2e).

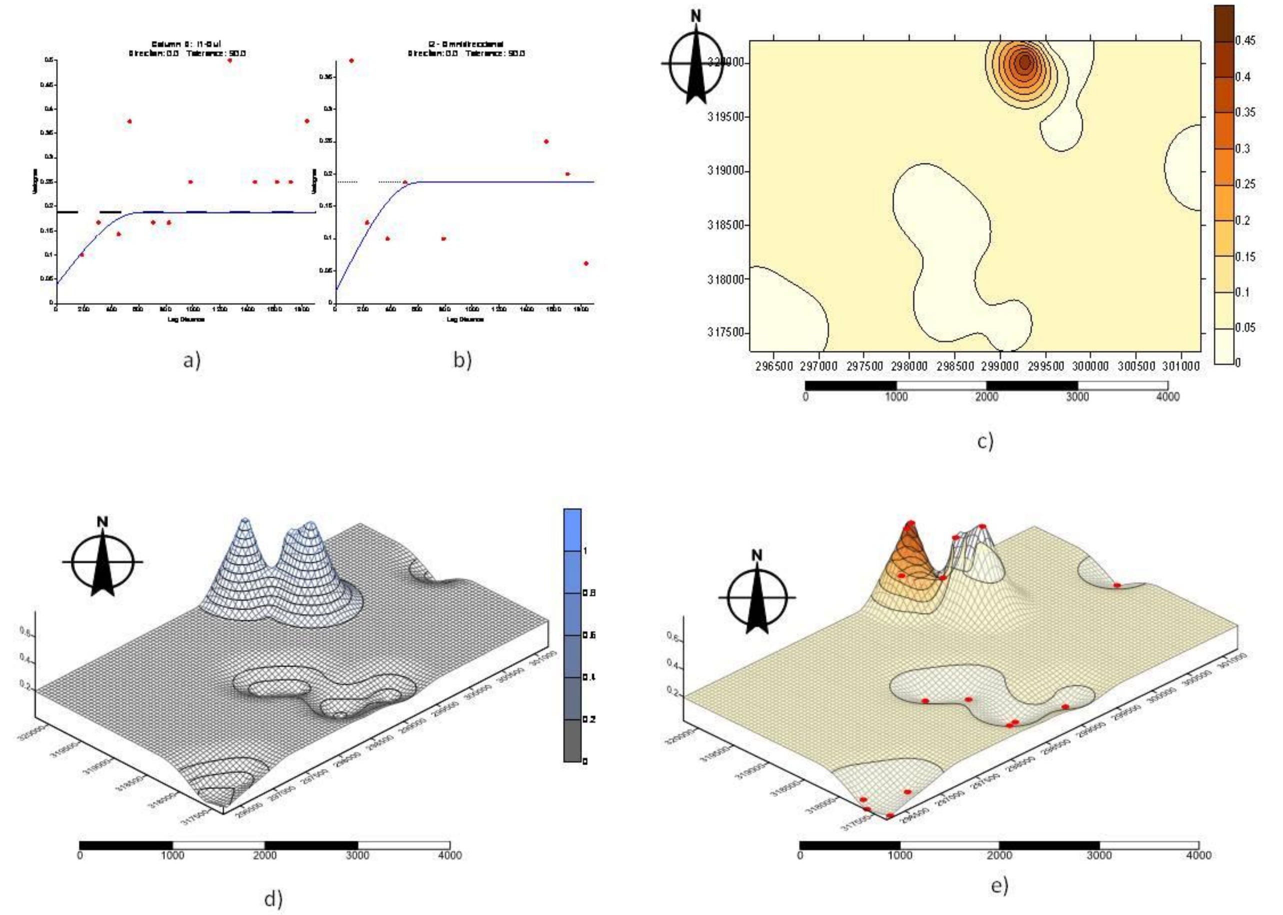

Fig.2 – a) and b) Varigrams and spherical modles fitted; c) Arsenic estimated map; d) Iso-probabilities map; e) Overlaid c) and d) maps.

4. REFERENCES

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