GEOSTATISTICAL ASSESSMENT OF THE RISK OF SOIL CONTAMINATION USING SOIL MAGNETOMETRY

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Introduction

Soil magnetometry is a method that is commonly used for fast screening of potential soil pollution with heavy metals. However, soil magnetic susceptibility measured in the field is not directly related to the concentration of Potentially Toxic Elements (PTE) in soil. Accordingly, field measurements of soil magnetic susceptibility need to be validated using chemical measurements. The goal of this study was to analyze methods of the geostatistical assessing the risk of soil contamination using soil magnetometry.

Methods

The study area of 12 km^2 was located in the Upper Silesian Industrial Area, in Poland. It was placed at the north-eastern edge of the Katowice agglomeration, in the direct vicinity of the Katowice steelworks. The majority of the study site was occupied by the forested areas with rather sparse network of roads. The habituated areas were located mostly at the edges of the study site. In the center of the study site there was located a reservoir with the area of about 0.75 km^2.

Soil magnetic susceptibility (κ) was measured using the Bartington MS2 Magnetic Susceptibility System, specifically the MS2D loop sensor. At selected location 10 to 15 single readings of soil magnetic susceptibility were made in the circle with a radius of 2 m, to obtain the average value, representative for the measured point.

Apart from the field measurements, soil magnetic susceptibility was measured in the laboratory using soil cores collected in the field. Soil samples were cut from this part of soil cores that was located between 0 cm and 10 cm below the soil surface. Mass specific magnetic susceptibility (χ) was determined using MS2B Bartington device.

Chemical measurements were carried out using sub-samples that were cut from the collected soil cores. In particular the top 10 cm of the soil core was used, because it was the maximum penetration depth of the MS2D sensor. Soil sub-samples were dried in room temperature, and after that sieved through a 1 mm sieve. After the soil samples were digested the BCR sequential extraction procedure was used to determine the concentration of PTEs in soil.

Results

Spatial distributions of soil magnetic susceptibility measured on the soil surface were calculated using ordinary and indicator kriging. The risk of the soil pollution was determined using magnetometric measurements and critical levels of soil magnetic susceptibility. These levels of κ were used as an indicator values in indicator kriging. Calculated probability maps make it possible to identify this part of the study area that were polluted. Simultaneously it was possible to calculate the spatial distribution of standard error. In a result, the advanced geostatistical assessment of potential soil pollution was done.

Conclusions

Results showed that the use of geostatistical methods made it possible to estimate the parameters of spatial variability of soil magnetic susceptibility and detect spatial outliers, even in a problematic area. A use of indicator methods enabled to calculate series of probability maps that were effectively used to assess the potentially polluted area. It was possible even without a knowledge about the exact values of critical levels of soil magnetic susceptibility.

The determined risk of soil pollution was expressed as probability of exceeding the assumed critical levels that were used in indicator kriging. This approach allowed to compare spatial distributions of pollution for different critical levels of soil magnetic susceptibility.

Moreover, geostatistical assessment provided the means to calculate the estimation errors, such as kriging variance or standard deviation of estimated value of soil magnetic susceptibility.

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