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Corporación colombiana de investigación agropecuaria

EGU General Assembly 2020

Predicting spatial distribution of heavy metals in agricultural soils using electrical resistivity tomography technique 2D-ERT

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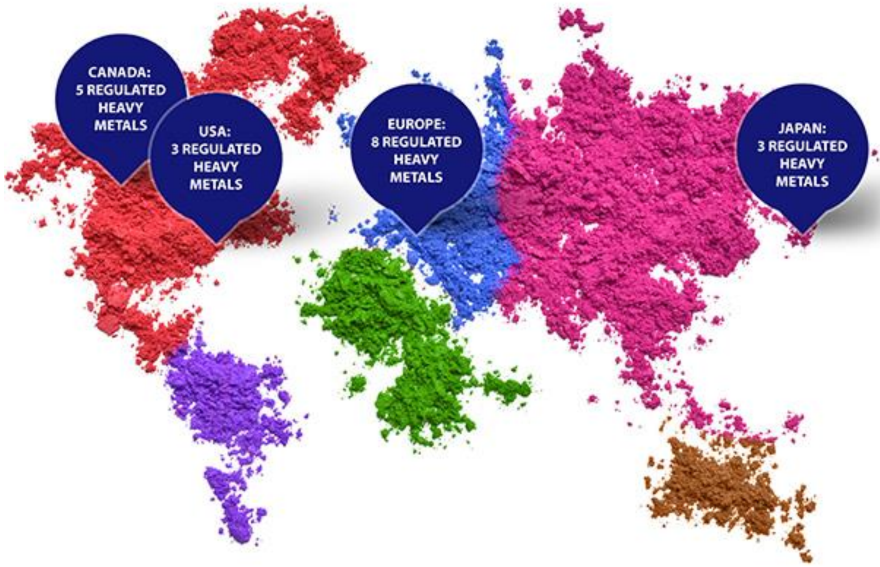
Overview

- Several hazardous heavy metals (HM) and metalloids (e.g., As, Pb, Cd, and Hg) are classified as non-essential to metabolic and other biological functions for crop production.

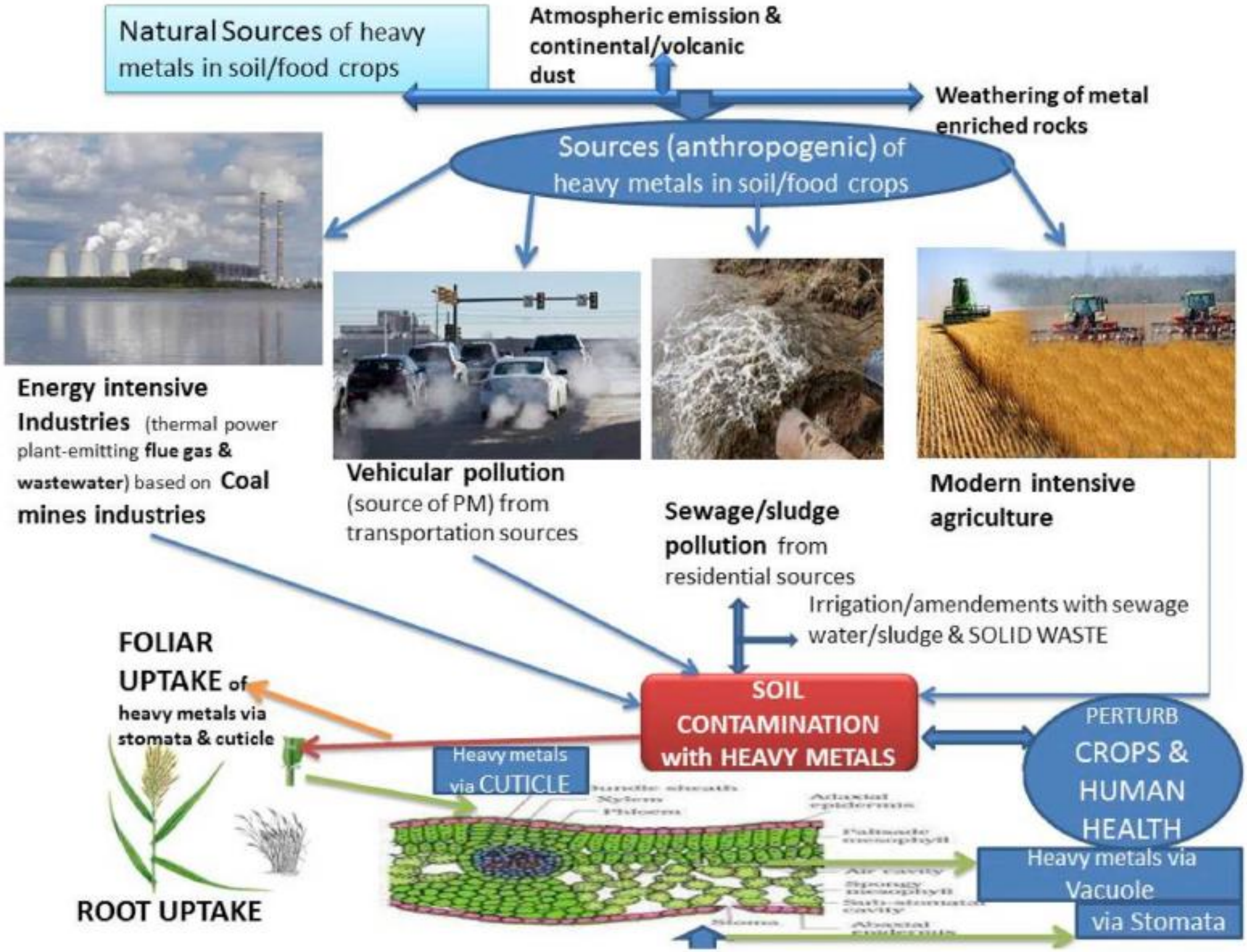
- Adverse effects of unexpected contaminants on crop quality have threatened both food security and human health by the contamination of water and soil resources.

- A key task is to characterize this contamination qualitatively and quantitatively in order to understand HM spatial distribution and decide about the adequate management.

- For future use of the polluted areas , the remediation process is an inaudible step to decrease environmental and human health risks.



Natural and anthropogenic sources of heavy metal contamination in food crops and mechanisms of their entrance with resulting impacts on biota and humans



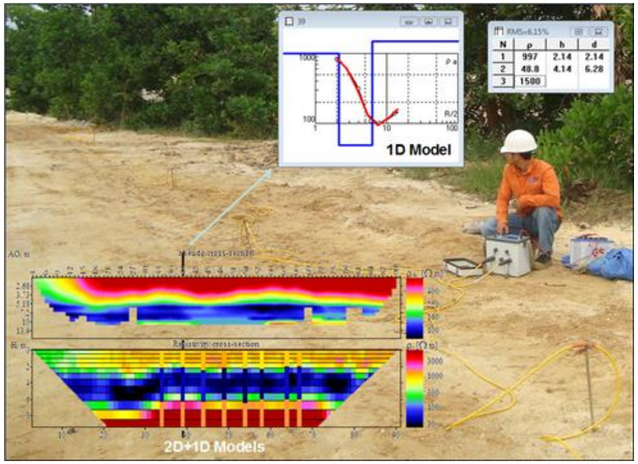
Source: P.K. Rai et al. 2019

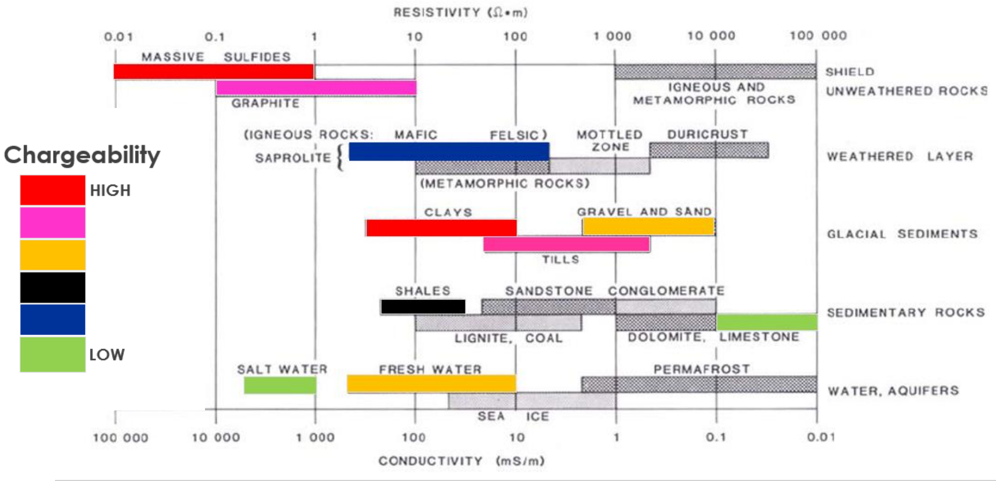
Overview

- Traditional sampling to monitor HM distribution is time, cost-consuming and often unrepresentative, fails in providing the needed information

- Sparse and punctual data measurements may not allow understanding the real dynamic of HM in the soil profile.

- In-situ geophysical techniques based on electrical resistivity tomography measurements (ERT) were implemented in agriculture as a “proxy” to determine spatial and temporal distribution of HM

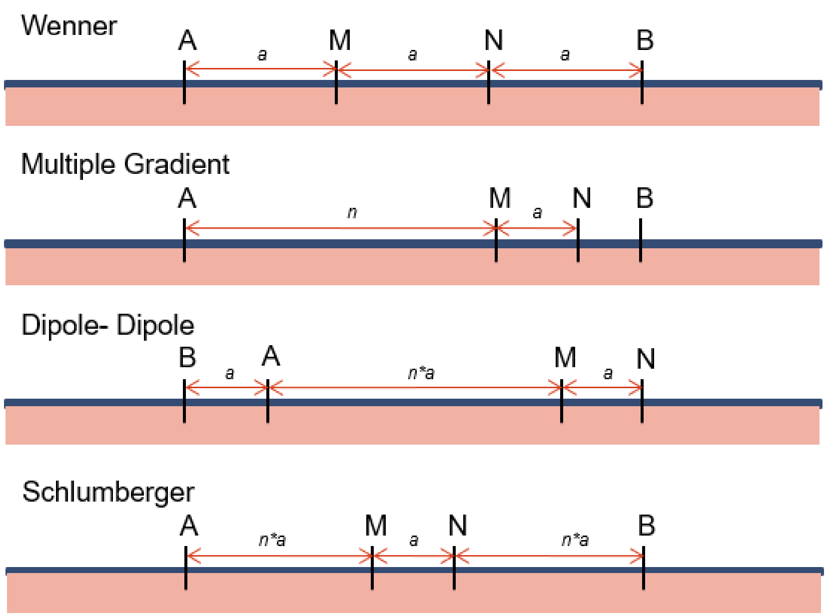




Overview

Resistivity is an active geophysical prospection method which measures the ground's electrical properties.

Electrode Arrays Configuration



Specifications

- Horizontal Layering
- Simple Conversion to Resistivity

- "Good Compromise" Array
- Multi-channel
- Good Signal-to-Noise Ratio

- Vertical Structures
- Multi-channel
- Increased Noise

- Horizontal Layering
- Less Work in the field

Objective

The objective of this study was to provide an accurate information for future efficient measures of soil remediation, by understanding the HM distribution, specifically cadmium (Cd) and arsenic (As), using electrical resistivity measurements combined with soil chemical analyses

Methodology

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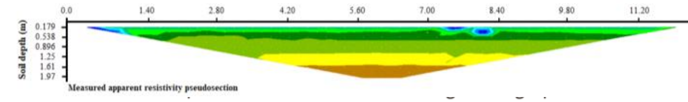
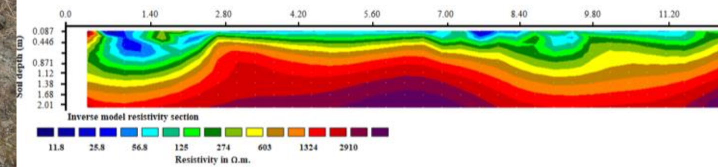
1) 9 Sites were selected

2) 2D-ERT Field installation UNI-T UT523A devise: 36 electrodes with 0,33 m spacing



3) Pseudo-section



4) Inversed modelling using Res2Dinv software

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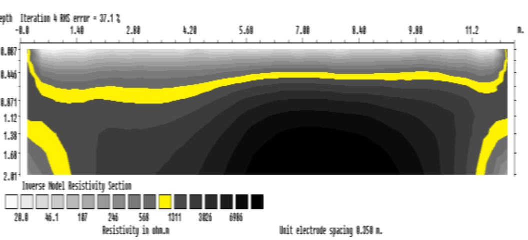
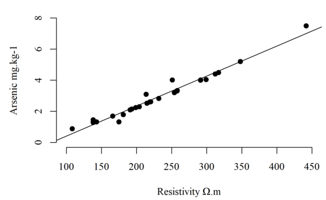
5) Soil pits and sampling



9) HM distribution prediction for Cd and As



8) Correlation of resistivity values with Cd and As

7) Laboratory Calibration

6) Laboratory Analysis for Cd and As

Methodology

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❖ *Important considerations*

- Geophysical study of this type of materials must be performed with techniques that combine good horizontal and vertical resolution.
- Wenner array is usually applied for a good vertical resolution, but may also provide a reasonable horizontal resolution
- Pseudosections are difficult to work with, they need to be converted into sections with true resistivity values and depths through a data inversion procedure that facilitates interpretation.
- The Res2Dinv program employs a 2D model of rectangular blocks, whose distribution is controlled by the data distribution in the apparent-resistivity pseudosection.
- Statistical techniques have been applied to data acquired to detect inter-relationships among the different observed variables. In particular, regression models have been used for evaluating correlations between resistivity coming from 2D-ERT and Cd and As content.

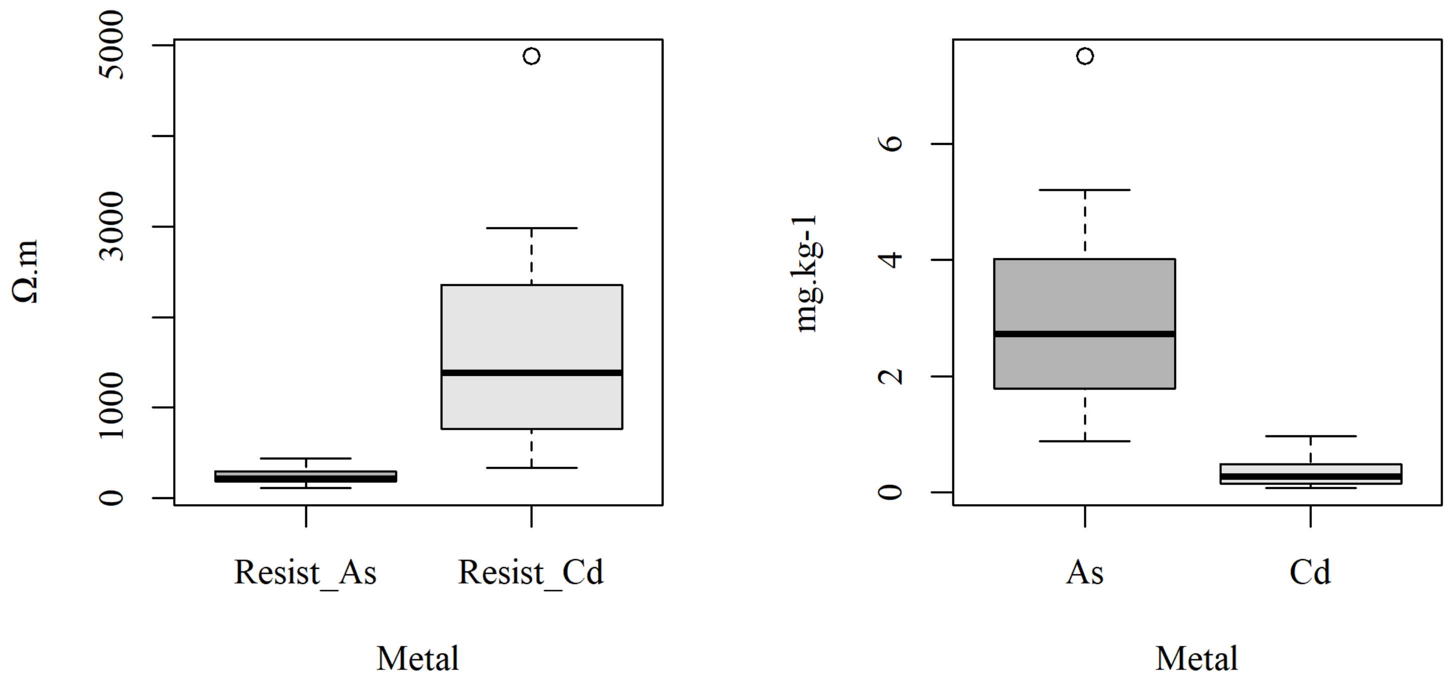
Results and Discussion

Sample	pH	As (mg.kg^{-1})	Cd (mg.kg^{-1})	Soil T*	Altitude **	Depth***	EC (dS m^{-1})
Site 1	6.59	1.79	0.33	29.27	369	40	0.20
Site 2	6.85	4.02	0.40	31.10	339	40	0.10
Site 3	6.58	3.10	0.52	25.93	470	75	0.00
Site 4	5.98	1.46	0.60	30.40	484	50	0.50
Site 5	6.14	1.93	0.55	30.33	293	50	13.70
Site 6	6.53	1.87	0.97	26.17	309	70	0.30
Site 7	6.75	1.32	0.58	32.14	315	70	1.20
Site 8	6.59	1.55	0.28	31.78	335	70	5.90
Site 9	6.94	1.57	0.87	31.98	313	50	0.70
Mean	6.55	2.07	0.57	29.90	358.56	57.22	2.51
SD	0.31	0.90	0.23	2.37	70.65	13.94	4.58
Max	6.94	4.02	0.97	32.14	484	75	13.70
Min	5.98	1.32	0.28	25.93	293	40	0.00

Soil T*: Soil Temperature (°C); SD: standard deviation; Max: maximum; Min: minimum.
**masl
*** cm

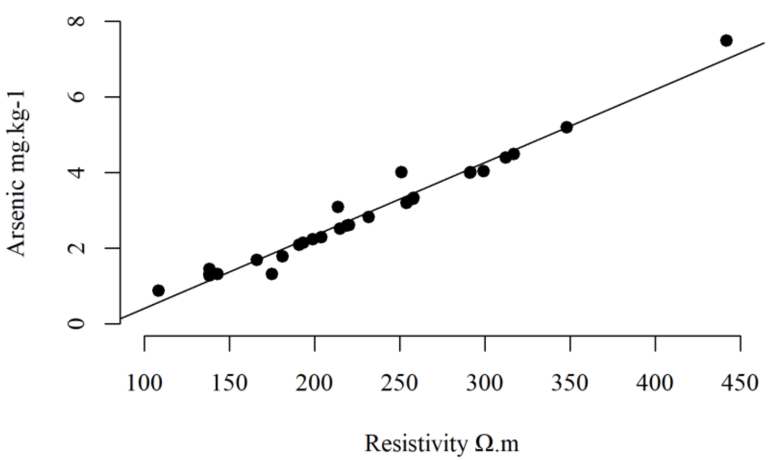
Descriptive statistics for studied variables within 9 sites

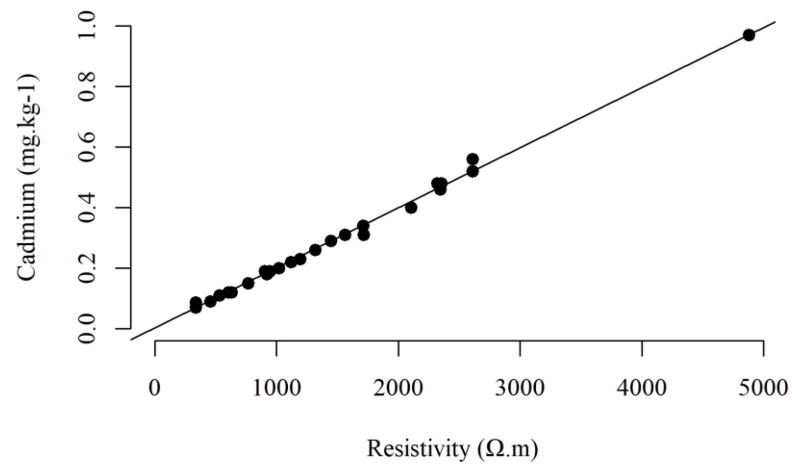
Results and Discussion



Boxplot of resistivity and metal content

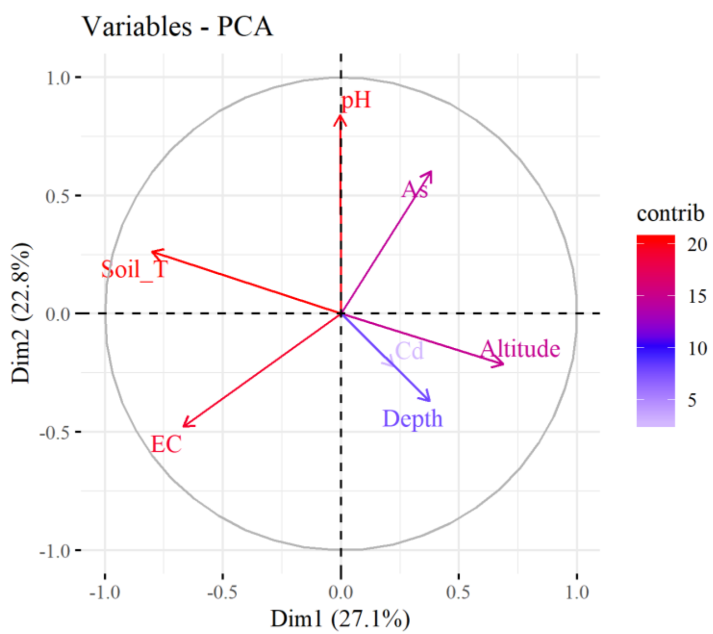
Results and Discussion

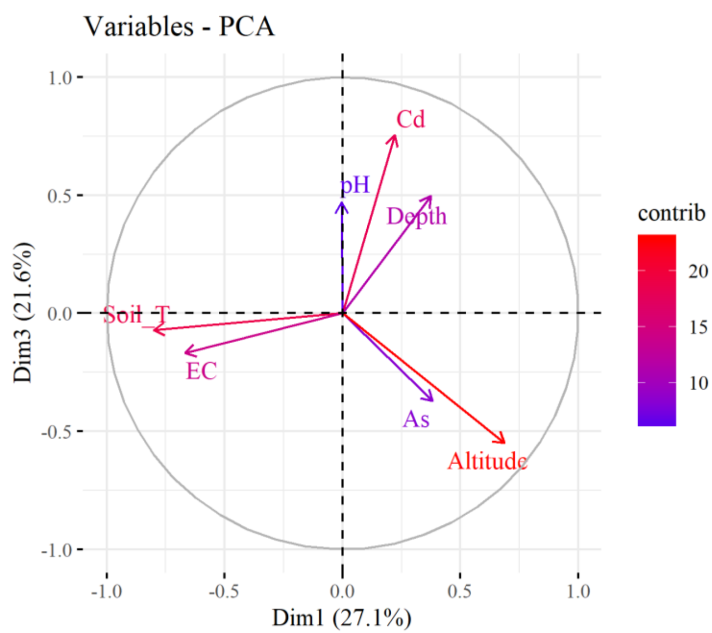




Scatterplot for resistivity Vs Cd and As

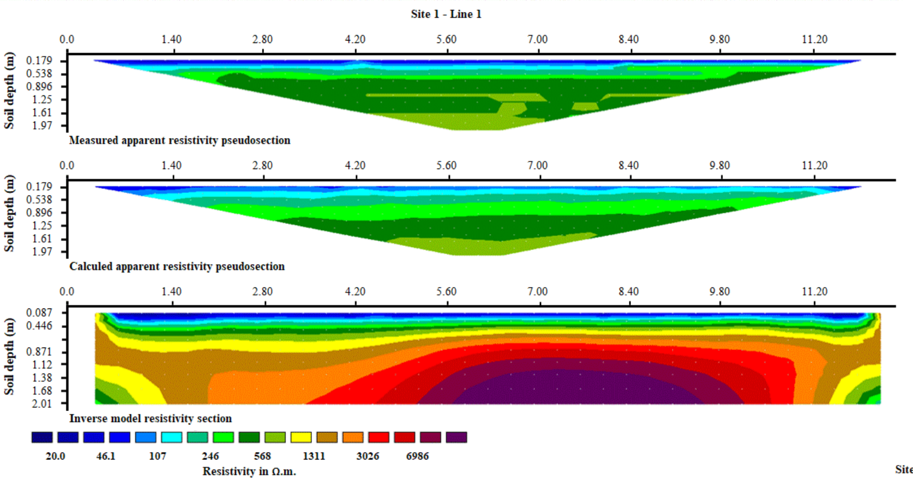
Results and Discussion

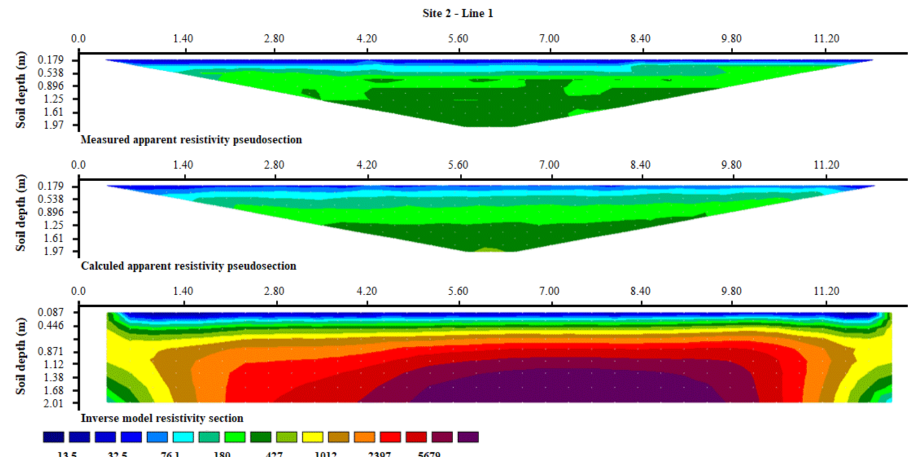


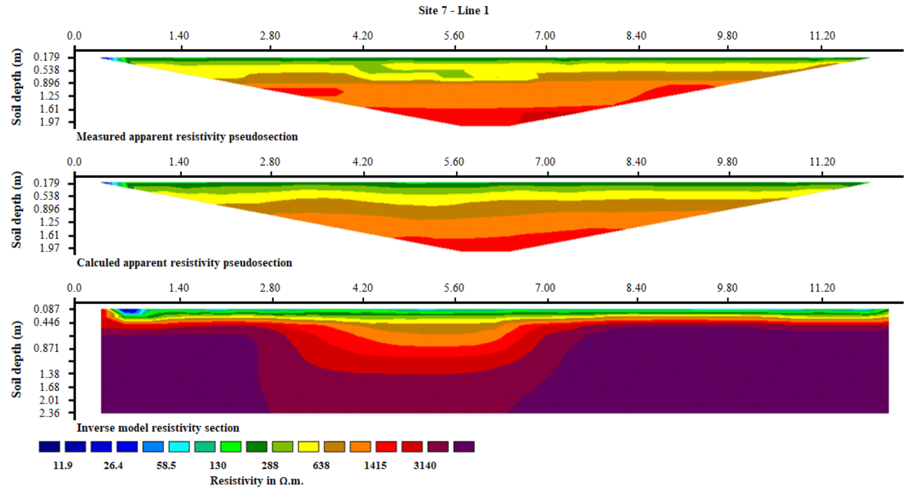


Graphic representation of Principle Component Analysis PCA

Results and Discussion







Example of electrical resistivity tomography for 3 sampled sites

- ✓ **9 localities were studied**
- ✓ **In each site 3 lines of 36 electrodes were installed, a total of 12 m per line**

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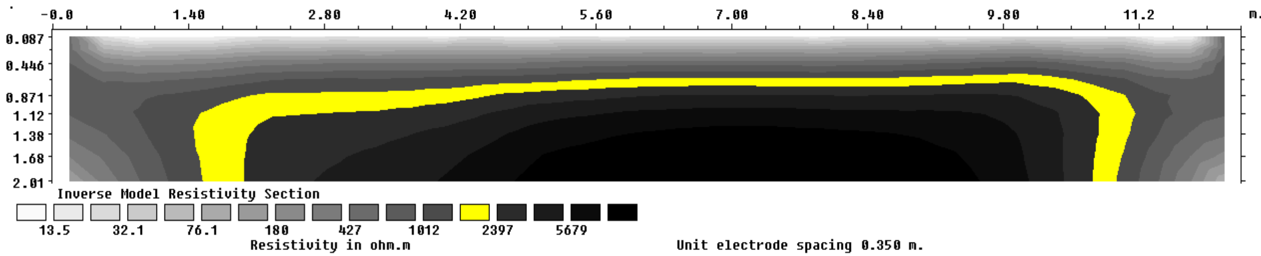
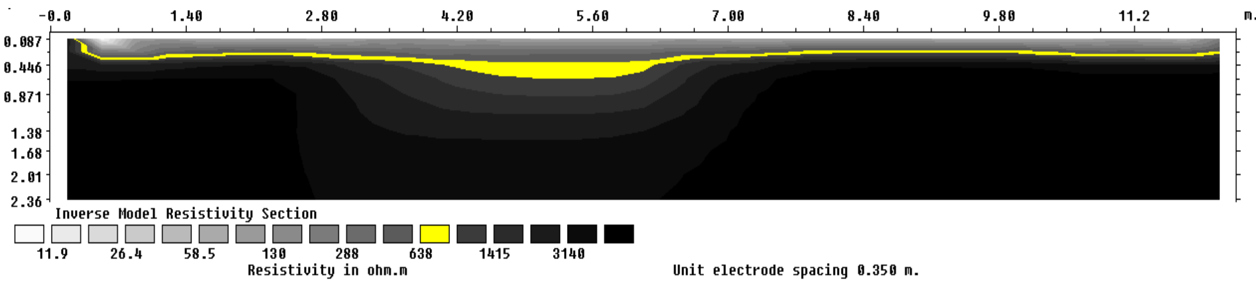
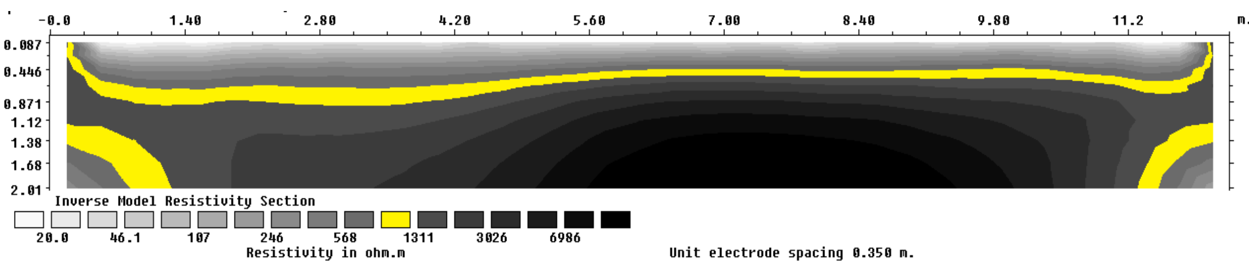
Results and Discussion



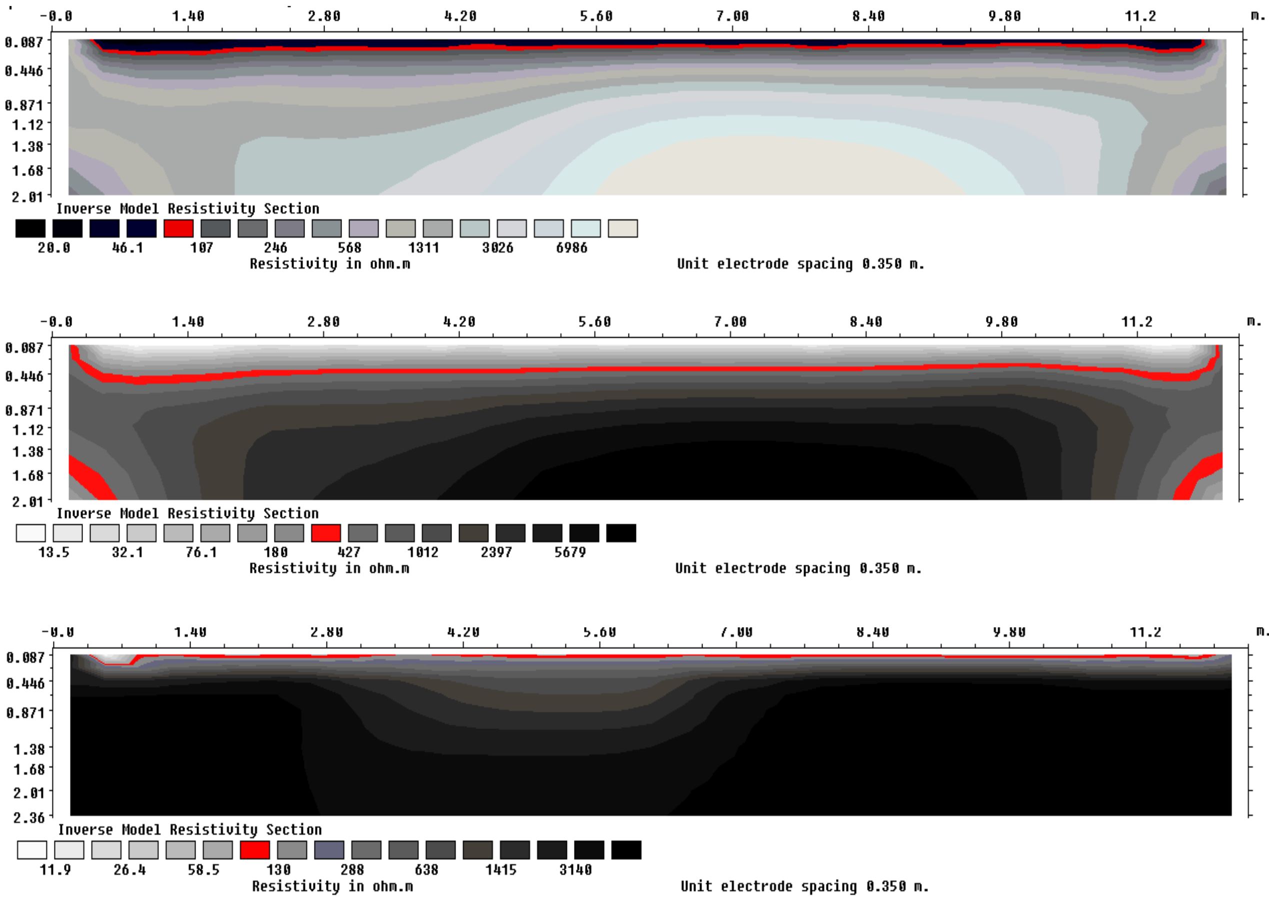




- ✓ Tomograms revealed that Cd distribution was mainly observed in deeper soil profiles

Predicting spatial distribution of Cd in 3 different sites using electrical resistivity tomography technique 2D-ERT

Results and Discussion



- ✓ Tomograms revealed that As distribution was mainly observed in shallower soil profiles

Predicting spatial distribution of As in 3 different sites using electrical resistivity tomography technique 2D-ERT

Conclusions

- ✓ Higher electrical resistivity values (330–4800 Ω.m) correspond to Cd distribution and lower electrical resistivity values (138-291 Ω.m) are related to As distribution.

- ✓ A high positive Pearson correlation (ρ) between electrical resistivity measurements and Cd and As chemical concentration was obtained for the nine locations; ρ values of 0.97 and 0.98 were obtained for Cd and As; respectively.

- ✓ A linear regression was performed between ERT measurements and Cd and As contents; (R^2=0.94, RMSE=0.33) and (R^2=0.97 RMSE=0.18) for Cd and As; respectively.

- ✓ The results underlie the utility of the combined geophysical techniques, based on electrical resistivity measurements, and soil chemical properties to improve the understanding of HM dynamic.

Many thanks for your attention!

Land & Water Resources Management
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