The Electrical Signature of Soils Contaminated by Heavy Metals
Research Plan & Preliminary Results

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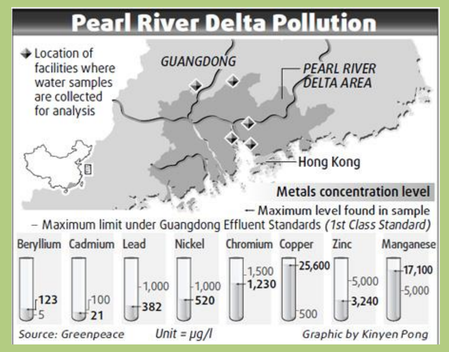
Hypothesis and Objectives

- Heavy metals will have strong geophysical signature, because they have high affinity to sorption and likely low mobility.
- We aim to study the effect of heavy metals on the electrical signature through experiments and to develop and calibrate a simplified model for the identification of heavy metals based on the SIP signature of the soil.

Introduction

Pollution in soil and water constitutes a threat to human health, especially in developing countries, such as China. For example, 40% of the agricultural soil in the Pearl River delta (southern China) is contaminated by heavy metals such as cadmium, mercury, nickel and copper.

Traditional methods of sampling and analysis, that involve drilling and tedious laboratory analysis, are slow and expensive as they require a large amount of the samples in order to characterize the area. Further, sample based analysis provides point-data with very little information regarding the area between sampling points. Geophysical measurements allow in-situ non-invasive and non-destructive analysis of the soil and could be the answer to that problem.

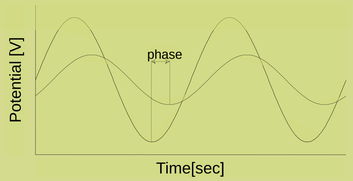


Spectral Induced Polarization

SIP method is based on injecting oscillating current at a range of frequencies and measuring the resultant potential, from which the complex conductivity (σ^*) can be calculated.

$$\sigma^* = \sigma' + i\sigma''$$

$$\theta = \tan^{-1}\left(\frac{\sigma''}{\sigma'}\right)$$

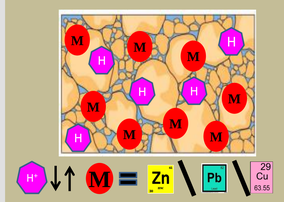


Stern layer polarization is the main mechanism that influences SIP signature at low frequencies, and it depends on the particle's size and on the valance, concentration and mobility of the adsorbed and dissolved ions. SIP is sensitive to contaminants absorbed onto the surface of the soil solids and can potentially identify the content and composition of heavy metals in the soil.

$$\sigma_s^{r_0} = \frac{2}{r_0}\left[e\sum_{j=1}^{N}|z_j|\beta_j\Gamma_j^d + e|z|\beta\Gamma_s\left(1-\frac{1}{i\omega\tau_0}\right)\right]$$

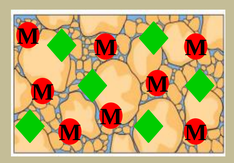
Research Plan

I



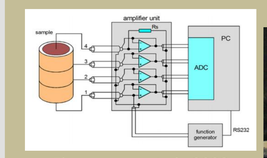
Studying the electrical signature of the main metals polluting the PRD - Mixing single metal, at different concentrations, in saturated mono-ionic Loess soil, over a range of pH values.

II



Studying the electrical signature of the metals in a more realistic situation – a mixture of several metals or of metals with other contaminants

System setup



Zimmerman et al., 2008

III

Developing both a data-driven and a mechanistic (tentatively stern-layer-based) model that will describe the connection between heavy metals and the electrical signature of soil.

IV

Applying the SIP technique in- and off-situ in the contaminated areas in the PRD in order to calibrate the model and adapt it to the conditions surrounding at the research area. This stage will be conducted in collaboration with researchers from Sun Yat-Sen University in Guangzhou, China.

Preliminary Results

Lead

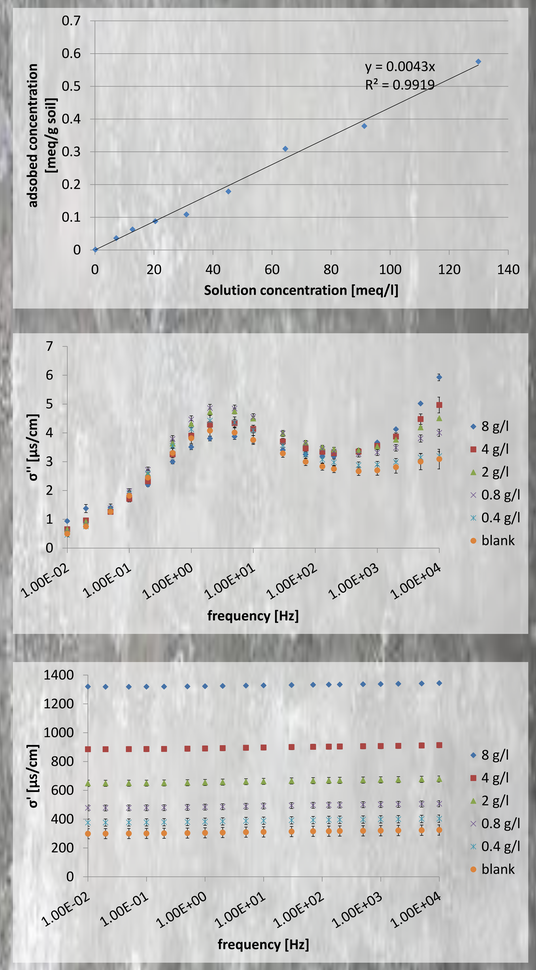


Figure 1: Sorption isotherm for Lead on Loess soil (top); Quadrature (middle) and In-phase (bottom) conductivity for different concentration of $PbCl_2$ solution in Loess soil.

Copper

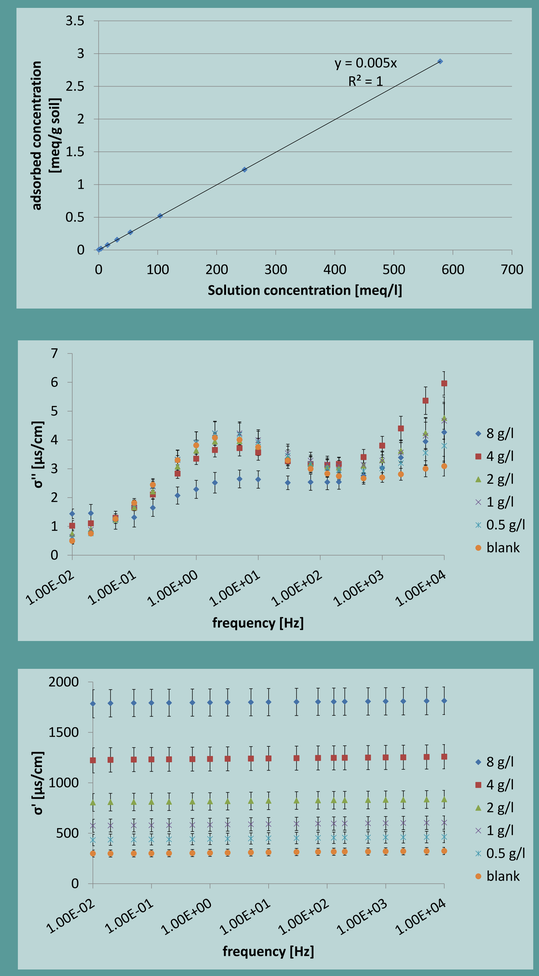


Figure 2: Sorption isotherm for Copper on Loess soil (top); Quadrature (middle) and In-phase (bottom) conductivity for different concentration of $CuCl_2$ solution in Loess soil.

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