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MASTER'S THESIS IN

ENVIRONMENTAL ENGINEERING

APPLICATION OF LACTUCA SATIVA FOR PHYTOREMEDIATION OF PREVIOUSLY CHEMICALLY TREATED CONTAMINATED SOILS

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ABSTRACT

Metal pollution of soils is one of the world's most serious environmental problems and researchers are making good progress with developing our understanding of many soil-related issues.

In recent years, environmental pollution has increased considerably and there is the need to find efficient technologies that allow restoration of contaminated sites, and simultaneously achieve the goals of environmental quality required by the legislation. Several techniques have been used over the years to resolve or at least reduce the problem of metal contamination in the environment.

Appropriate technologies for remediation and safeguarding of contaminated sites are based on physical, chemical or biological processes, which can decontaminate the soil or stabilize the pollutants inside of it. The cleansing reduces the amount of pollutants in the soil, while the stabilization uses soil amendments (fertilizers that improve the physical characteristics of the soil) or otherwise alters the chemistry of the soil and sequesters or absorbs the pollutants into the matrix, reducing the environmental risks. The choice of the remediation strategy depends on the nature of the contaminant.

Within all the most traditional treatments, phytoremediation of contaminated soil is propagating because it is energy efficient and an aesthetically pleasing method of remediating sites with low–to–moderate levels of contamination.

Anyway, the number of plant species with the necessary capacity for accumulating metals from soils and the low bioavailability of metals, limits the technique.

The goal of this research is to investigate whether, to which extent and in which external conditions, *Lactuca Sativa* is capable of accumulating copper and zinc.

The specific goals of the thesis are:

- Assessment of the role of leaves and roots in removal of Zn and Cu from contaminated medium;
- Identification of accumulation capacity of the plants and their factor of translocation;
- Evaluation of potential toxicity of the metals concentrations in the plant samples;
- Determination of correlations between factors in reference to the plant.

The experimental work took place at the Czech University of Life Sciences Prague, Faculty of Environmental Science. The sampled soils were collected from a previously agricultural area, located in the municipality of Giugliano in Campania and undergone to a soil washing treatment at four conditions:

- with 0.36 mM EDDS for 1 and 96 h;
- with 3.6 mM EDDS for 1 and 96 h.

The uptake experiment was conducted during spring 2016 in the "greenhouse", under controlled conditions of temperature and humidity. The plants, already in the growth stage, were arranged in seven different soil samples; unpolluted soil, polluted but not soil washed soil and control samples (regular soil) were added to the four chemical washed ones.

Since each treatment was replicated ten times, the total amount of the samples was 70. After 21 days of exposition, the plants were ready to be extracted from the pots and the following steps have been:

- Separation of soil, roots and leaves;
- Drying;
- Pulverization;
- Mineralization;
- Mass spectrometry (ICP-MS).

Results of the data processing showed that the 90% of factors followed a Gaussian distribution, allowing a discussion in terms of means.

The distribution of metals between roots and leaves demonstrates the different accumulation of Cu and Zn in roots and in the aerial part (Figure 1) and that the previous treatments influenced the uptake in three up to four conditions of soil washing. The plants grown in the soil treated for 96 hours with a solution of 3.6 mM of EDDS were the exceptions to the trend. Once taken into consideration the weights, the total concentration turned to be approximately constant in all the samples.

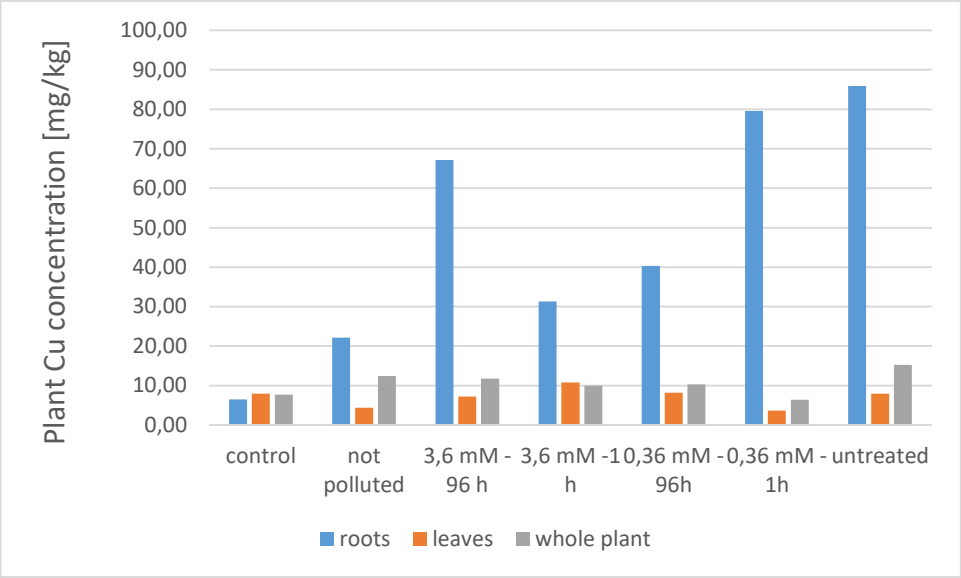

Figure 1: Metals distribution in roots, leaves and concentration in the whole plant.

Furthermore, a correlation between EDDS concentration and Cu concentration in plant has been assessed, demonstrating the enhancing effect of the chelate (Figure 2).

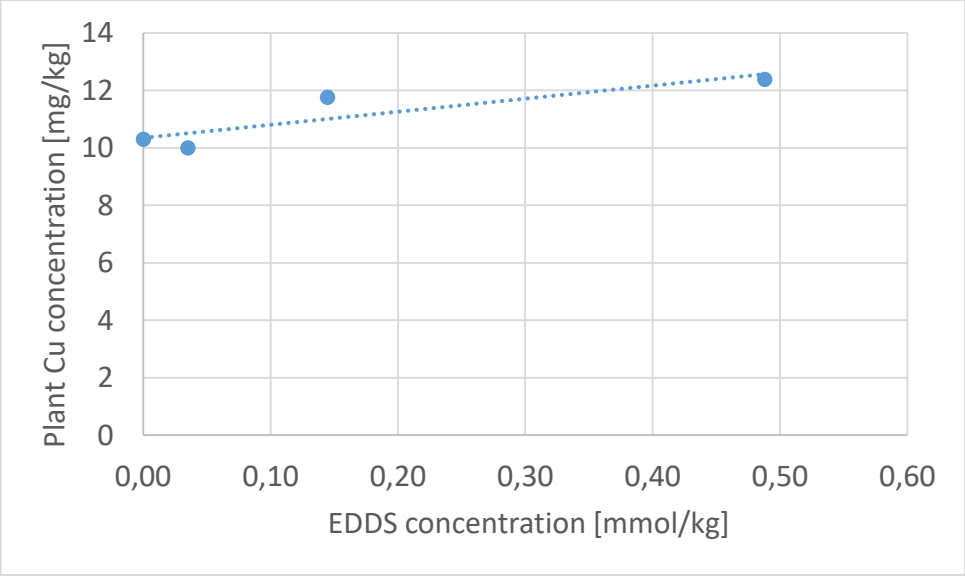

Figure 2: Plant Cu concentration and EDDS concentration

A direct proportionality has been also confirmed between Cu and Zn concentrations in roots. Plant samples that are good hyperaccumulators for Zn, likely they are good hyperaccumulators for Cu as well and that probably the two metals uptakes influenced each other.

Additionally, a transfer factor was evaluated to assess the mobility of metals by plants and it was defined by the following equation:

$$TF = \frac{C_{plant}}{C_{soil}}$$

where C_{plant} represents the metal concentration within the plant and C_{soil} the soil concentration before phytoremediation. For some samples, the Zn transfer factor was less than the minimum value reported in literature, determining a less efficiency of the process.

Through the definition of the *Plant health* coefficient, it has been demonstrated that to an increase of high metals in soil, corresponds a worsening of the plant condition, probably due to the length and weight of the roots, since from an external point of view there was no clear difference between the samples. Moreover, the *Plant health* coefficient determinates a confirmation of the non-toxicity of high metals in not washed soil (red sign) and that probably the values were not as worrying as initially assessed (Figure 3).

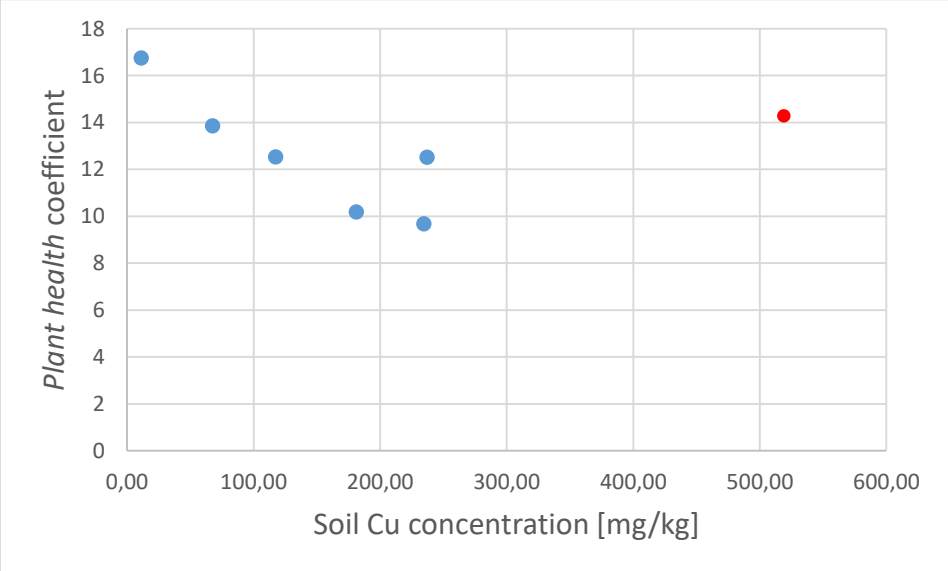

Figure 3: Plant health coefficient and soil Cu concentration. *Plant health* = RL+L+RW-DL with RL being the roots length after contamination (cm), L being the number of leaves, RW being the roots weight after contamination (g), DL the number of dead leaves.

Within the statistical analysis, the Spearman coefficient has been evaluated to assess the correlation between several factors as follow:

$$\rho s = \frac{cov(r_A; r_B)}{(\sigma_A * \sigma_B)}$$

where $cov(r_A; r_B)$ is the covariance of the rank variables of each observation and σ_i the standard deviation.

A direct correlation between leaves weight and Zn concentration in the whole plant was determined, confirming that the best and more the plant grows, more it accumulates the high metals in its tissues. Another interpretation could be that the accumulation of Zn in the plant does not reach a critical toxic value for the plant, which shows always a good-looking aspect. In fact, the ρs value confirmed no correlation between the Cu and Zn concentrations in plants and dead leaves, even if not acceptable at the significance level of 0.05.

Furthermore, thanks to the evaluation of Spearman coefficient, it has been assessed that if the roots weight is maximized, an increase of the absorption of metals through the roots structure occurs and so the rise of metal concentration in the whole plant.

At the conclusion of this work, it can be assumed that *Lactuca Sativa* showed a good behaviour as hyperaccumulator and an important opportunity could be the continuation of this project. Surely, a greater effectiveness of soil remediation may require longer times, which in this experimental work were too short in order to have a significant result.