THE INFLUENCE OF THE NUTRIENTS AND THE SOIL pH ON CADMIUM AND ZINC UPTAKE BY THE *BRASSICA NAPUS*

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Abstract. The paper presents studies concerning the effect of application of nutrients and the soil pH changes on the phytoremediation potential of *Brassica napus*. The soil was collected around the metal plating factory from Iasi County, Romania. Soil pH was adjusted to 6.0, 7.0 and 8.0 by the addition of Na_2HPO_4. The nutrients containing 15% nitrogen, potassium and phosphorus and were applied in quantities of 2 g, 4 g and 6 g. *Brassica napus* was grown in enameled steel pots in greenhouse conditions, being irrigated with a constant amount of water every tree days, during a total time of experiment of 70 days. The plant was sowed in two replicates using the selected seeds and the pH of soil mentioned above. Harvesting was made at the end of the vegetation period and the distribution of Cadmium and Zinc ions content in roots, shoots and leaves was pointed out. We have been observed that *Brassica napus* produced greater biomass in the pH range 7.0 – 8.0 than at pH 6.0. Regarding the influence of nutrients, they have contributed to the increase of plant biomass but not in the accumulation of highest amounts of Cd and Zn. The content of Cadmium and Zinc in both soil and plants samples were determined using Atomic Absorption Spectrometry. Taking in consideration the best removal performances and the biomass production of *Brassica napus*, the recommended pH of soil is 8.0.

Keywords: *pH, cadmium, zinc, uptake, Brassica napus.*

1. Introduction

Phytoextraction has gained world-wide attention as an environmentally friendly and potentially cost-effective technique to remove Cadmium (Cd) and Zinc (Zn) from soil. The use of hyperaccumulating plant species has been suggested as a promising strategy for phytoextraction (McGrath et al., 2001).

Removal rates of metals from contaminated soils by plants are highly dependent on soil properties, degree and bioavailability of metal contamination, and, obviously, metal uptake characteristics and biomass production of the plant species used for remediation (Lasat, 2000, Babeanu et. al., 2010, Cojocaru et. al., 2012).

pH is one of the most important factors (Kukier et al., 2004) which controls the uptake of the heavy metals (Barančiková et al., 2004; Seuntjens et al., 2004; Amini et al., 2005; Basta et al., 2005). Lower pH of the soil solutions increases cation solubility but resultant plant uptake may be mediated by soil nutrient levels and the inability of plants to thrive at lower pH values (Zaurov et al., 1999; Sauve´ et al., 2000).

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The nutrient level also affects bioavailability. Göthberg et al. (2004) grew the aquatic macrophyte water spinach (*Ipomoea aquatica*), which is a widely used vegetable in Southeast Asia, in Hoagland's solution with different strengths (1, 10, 25, 50, 100%). Cadmium was added as cadmium sulfate to the nutrient solutions (0, 0.9, 9, 27, 45 μM Cd). They measured Cd in the leaves, stems, and roots. Uptake of Cd depended on the strength of the nutrient solution. They found that the lower the nutrient strength in the medium was, the higher were the metal concentrations that accumulated in different parts of the plant. However, contrary to this main finding, Cd concentrations in the leaves, stems, and roots of untreated plants were higher at the high rather than the low strength of nutrient solution.

The main aim of this article, done in the frame of soil phytoremediation studies, is to determine the influence of nutrients and the soil pH upon the best removal performances of cadmium and zinc ions (heavy metals uptake) using a promising plant namely *Brassica napus.*

2. Materials and methods

2.1. Sampling, processing and characterization of soil samples

Soil polluted with Cadmium and Zinc was collected around the metal plating factory from Iasi County, Romania, from the surface up to a depth of 30 cm. Concentrations of Cadmium and Zinc were determined by Atomic Absorption Spectrometry, after a prior mineralization of samples.

Soil pH was adjusted to 6.0, 7.0 and 8.0 by the addition of Na_2HPO_4. The nutrients containing 15% nitrogen, potassium and phosphorus were applied in quantities of 2 g, 4 g and 6 g. Each experimental variety, respectively pH range 6.0, 7.0 and 8.0 and nutrients, was used in two replicates.

The physicochemical parameters were measured by standard methods. Soil texture was determined by the hydrometer method. The moisture content of soil was calculated by the mass difference before and after drying at 105°C to a constant mass. Total phosphorus, total potassium, nitrate, nitrite, sulphate and chloride were determined according to the standardized methods as mentioned in previous article (Cojocaru et. al., 2011). Total nitrogen was determined by using Kjehdahl method and total organic carbon using Walkley-Black method (Cojocaru et. al., 2011).

2.2. Methodology of Greenhouse Experiments

The greenhouse is situated in the frame of the metal plating factory, made by glass walls and glass roof. The experiments were carried out under greenhouse conditions, very similar with field conditions, but under controlled parameters: temperature (25 ± 3°C), sun light intensity (3500-± 400 lux), relative humidity (70 ± 10 %) and air ventilation (natural ventilation depending on the atmospheric conditions).

Greenhouse pot culture experiments were conducted in enameled steel pots in greenhouse conditions, being irrigated with a constant amount of water every tree days, during a total time of experiment of 70 days.

Brassica napus has been sowed in two replicates using the selected seeds provided by the Central Laboratory for Seeds and Propagating Material Quality, Bucharest, Romania.

In each enameled steel pot was put 7 kg of soil polluted with cadmium and zinc with different range of pH (6.0, 7.0 and 8.0) and nutrients (2 g, 4 g and 6 g) and 10 seeds per pot. During the growing season the following observations on plants growing were done: counting of plant seedlings and measuring plant length. Plants were harvested at the end of vegetation (10 weeks after sowing) and then separated into roots, shoots and leaves. The roots were washed with distilled water to remove any adherent soil. Based on these data the total quantity of biomass production was determined.

After harvesting the total amount of Cadmium and Zinc in the plant tissue and in the soil was determined, taking in consideration the initial concentration of heavy metal ions in soil samples.

3. Results and Discussions

The initial contents of cadmium and zinc in the soil samples are presented in Table 1.

Table 1: The initial contents of cadmium and zinc in the soil samples

Parameter	***Value /amount***	***Heavy Metal Content (mg/kg d.w.)***	
		Cadmium	***Zinc***
pH	6.0	56.78	426.44
	7.0	40.56	545.74
	8.0	46.39	272.84
Nutrients	2g	54.90	412.42
	4g	36.26	420.46
	6g	41.73	400.62

The soil that contains nutrients, respectively 2g, 4g and 6g has pH 7.0.

The soil polluted with cadmium and zinc is characterized by the physicochemical properties presented in Table 2.

Table 2: Physicochemical properties of the investigated soil

Characteristic parameter	***The analyzed soil sample***	
	P1	***P2***
Humidity (%)	10.95	9.32
Granulometry (%)	- sand: 23.20 - dust: 61.60 - clay: 15.20	- sand: 24.00 - dust: 61.20 - clay: 14.80
Total organic carbon (mg/kg d.w.)	6492	6986
Humus (mg/kg d.w.)	11361	12225
Total phosphorus (mg/kg d.w.)	299	308
Total potassium (mg/kg d.w.)	64	76
Total nitrogen (mg/kg d.w.)	586	602
Nitrate (mg/kg d.w.)	14.94	12.04
Nitrite (mg/kg d.w.)	0.62	0.84
Sulphate (mg/kg d.w.)	1232	1184
Chloride (mg/kg d.w.)	40.62	38.92

Seed germination rate, shoot length and the total biomass production for each value of pH and nutrients studied is presented in Table 3.

Table 3: Seed germination, shoot length and biomass production

Parameter	***Value /amount***	***Germination rate (%)***	***Shoot length (cm)***	***Biomass production (g)***
pH	6.0	20	15.23	5.33
	7.0	40	27.50	10.10
	8.0	85	31.40	13.25
Nutrients	2g	90	37.80	21.88
	4g	95	46.38	33.19
	6g	96	47.50	44.25

According to the data presented in Table 3, the highest seed germination rate and the highest amount of biomass was recorded at a pH value of 8.0. It can be seen that the greater amount of nutrient is higher, so the germination rate, shoot length and plant biomass is greater.

The amount of Cd(II) and Zn(II) ions contained in plant tissues used in phytoremediation for each studied pH value can be seen in the Figures 1-3.

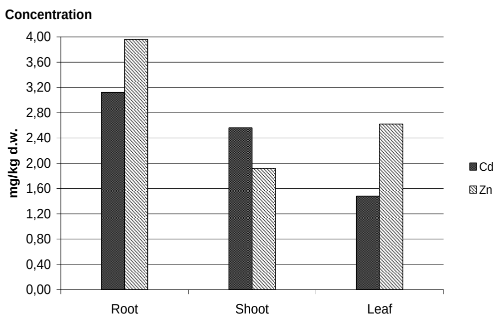

Figure 1: Concentration of Cd(II) and Zn(II) in the root, shoot and leaf of Brassica napus at pH value of 6.0

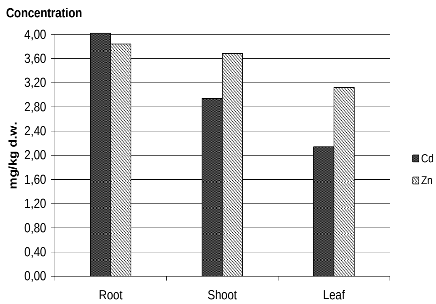

Figure 2: Concentration of Cd(II) and Zn(II) in the root, shoot and leaf of Brassica napus at pH value of 7.0

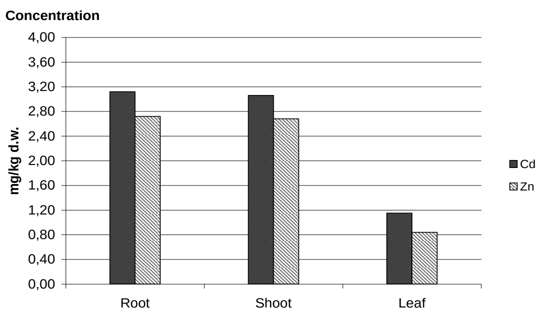

Figure 3:Concentration of Cd(II) and Zn (II) in the root, shoot and leaf of Brassica napus at pH value of 8.0

Regarding the amount of Cd(II) and Zn(II) ions contained in plant tissues as a result of the use of nutrients can be seen in the Figures 4-6.

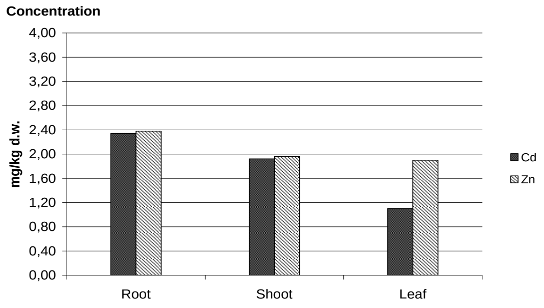

Figure 4: Concentration of Cd(II) and Zn(II) in the root, shoot and leaf of Brassica napus after using 2 g of nutrient

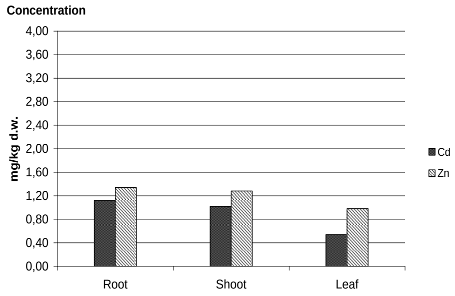

Figure 5: Concentration of Cd(II) and Zn(II) in the root, shoot and leaf of Brassica napus after using 4 g of nutrient

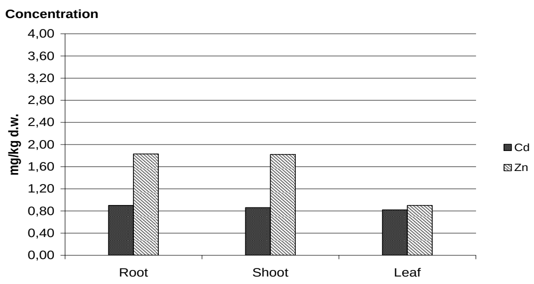

Figure 6: Concentration of Cd(II) and Zn(II) in the root, shoot and leaf of Brassica napus after using 6 g of nutrient

The amount of Cd(II) and Zn(II) ions contained in soil before sowing and after harvesting can be seen in the Figures 7-8.

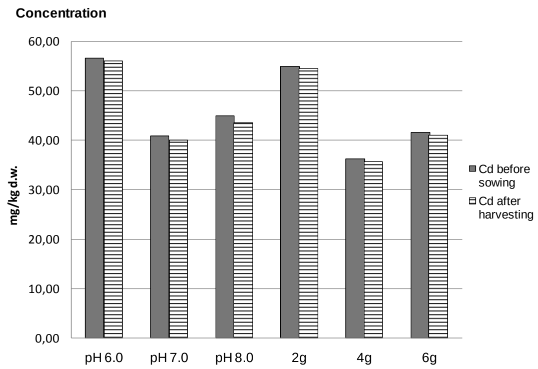

Figure 7: Concentration of Cd(II) in soil before sowing and after harvesting the plants

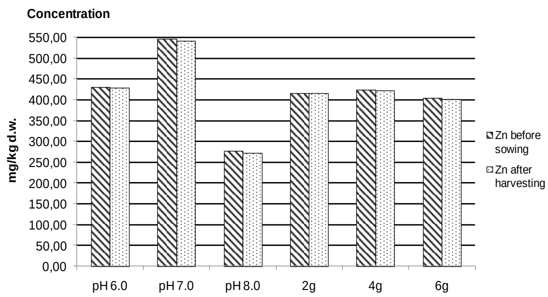

Figure 8: Concentration of Zn(II) in the soil before sowing and after harvesting the plants

The efficiency of using the nutrients and the soil pH on Cadmium and Zinc uptake by the *Brassica napus* is presented in the Figure 9.

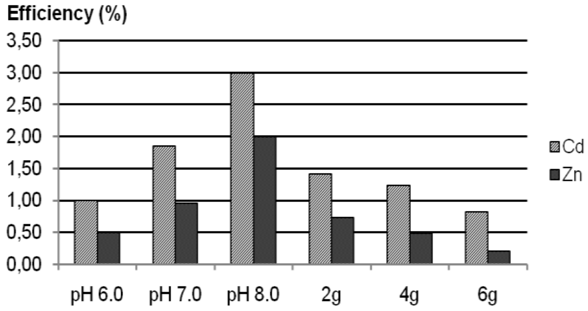

Figure 9: Efficiency of plants involved in the soil phytoremediation

The soil pH is an important parameter that influences the accumulation of Cadmium and Zinc ions by plants including the *Brassica napus*. The largest quantities of both Cadmium and Zinc ions were accumulated in roots of the plant at pH 8.0. The Cadmium amount in plant tissues depending on soil pH as following: 7.16 mg/kg d.w. for pH value of 6.0; 9.20 mg/kg d.w. for pH value of 7.0 ; 9.80 mg/kg d.w for pH value of 8.0. The Zinc amount contained in plant tissues presented also a soil pH dependence as following: 6.24 mg/kg d.w. for pH value of 6.0; 7.30 mg/kg d.w. for pH value of 7.0; 8.70 mg/kg d.w. for pH value of 8.0.

At week acidic pH value of 6.0, seed germination was strongly affected and also the biomass production.

By application on the investigated soil, the smaller amount used in this study, the found amount of Cadmium and Zinc respectively was increased, together with biomass development..

Conclusions

The previous studies and presented research make evident the following conclusions:

The best removal performances toward cadmium and zinc ions (heavy metals uptake) were obtained by changing the soil pH. The maximum removal rate was obtained at the pH value of 8.0; for cadmium was 3.00 % and for zinc was 2.00 %.

Regarding the influence of nutrients, they have contributed to the increase in plant biomass but not in the accumulation of highest amounts of Cadmium and Zinc, respectively. As smaller amount from the applied nutrients, as higher the amount of Cadmium and Zinc respectively was found. The maximum removal rate was obtained at the addition of 2 g of nutrient, which corresponds to the cadmium removal rate of 1.42 % and respectively for zinc of 0.73 %.

This study could be useful for understanding the importance of the soil parameters, especially the pH influence, on the accumulation of Cadmium and Zinc by *Brassica napus*. Future research can be enhanced, using different plants and different types of pollutants.

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