Effects of heavy metals accumulation on the growth and essential oil content of Rose Geranium (*Pelargonium graveolens* L'Her).

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Abstract

The objective of this study was to investigate the accumulation of Cd, Ni and Pb in the aboveground and underground parts of Rose Geranium (*Pelargonium graveolens* L'Her), as well as the effect on the plant's content of essential oil. A pot experiment was conducted using four different levels of Cd, Ni or Pb, in five replications. Analyses of the aboveground tissues were conducted after 10 and 14 weeks of exposure. At the end of the experiment, aboveground and underground biomass of the plants was air dried until constant mass. Samples were analysed with ICP for their heavy metal content. Essential oils were extracted by hydrodistilation and GC-MS analyses were carried out. Results show metal- and pollution level- dependent accumulation of the three metals in the roots and the aerial parts of the plants. Essential oil profiles show rather minor effects of heavy metal exposure on the essential oil composition.

Keywords: accumulation, essential oil, heavy metals, rose geranium, *Pelargonium graveolens*

1. Introduction

Heavy metal pollution is one of the most important abiotic stresses that present high-risk effects on the plants and animals, with influence on the growth and energy production processes (Maksymiec, 2007). Heavy metal pollution, is usually due to inadequate irrigation practices, industrial remains or constant usage of fertilizers. The high concentrations of heavy metals in the soil can generate toxicity in plants, and risk for human and animal health, or contamination of the water (Mahdieh et al., 2013; Yadav, 2010). Accumulation of the heavy metals in the plant tissues depends on the metal and the plant (Abu-Darwish, 2009; Rascio and Navari-Izzo, 2011). In the work presented here, the common in the Mediterranean countries aromatic plant *Pelargonium graveolens* L'Her, was examined for the accumulation of Cd, Ni and Pb in its roots and aboveground tissues, using ICP-OES. The effects of the metal pollution on the essential oil composition was examined by GC-MS. *P. graveolens* was selected due to its extended use in local cuisines, aromatherapy, cosmetics and perfumery industry (Miller, 2003).

2. Materials and Methods

Soil was collected from an unpolluted site in the area of Chania, Crete, and it was air dried and passed through a 6.35mm sieve before its use in the pot experiment. Soil samples were sieved (2mm) and analysed for the basic physicochemical properties and available nutrients. The soil pollution was conducted by mixing specific volumes of stock solutions of heavy metal nitrate salts with the soil, homogenization, and occasional mixing for 2 weeks. For each of the three heavy metals under study, four pollution levels were established, with five replications (Ni 20, 60, 200, 600 ppm; Cd 5, 10, 50, 100 ppm; Pb 50, 250, 500, 2500 ppm), whereas control pots received no application. The DTPA method for extraction was used to estimate the plant-available trace elements.

Cuttings of *P. graveolens* were cut during autumn and placed in peat soil for 5 weeks until transplanted in 1,8 kg of polluted and control soil. Analyses of the aboveground tissues were conducted 10 and 14 weeks later. At the end of the experiment, aboveground and underground biomass was collected, cleaned and air dried until constant mass. 0.2 to 0.3 g of the homogenized leaves, flowers and roots were ashed at 600°C for 5 hours and the ash was dissolved in 10 mL HCl 2 N. The solution was filtered, diluted to 50 mL and analysed using ICP-OES.

Dried leaves and flowers were submitted to hydrodistillaton for 6 hours using a Clevenger apparatus. The distilate was extracted with diethyl ether. The essential oil was separated from the water, dried over anhydrous sodium sulfate and analysed by GC-MS.

3. Results

Ni pollution results in serious reduction in roots biomass at the 200 ppm ($p<0.05$) and 600 ppm ($p<0.001$) levels (Figure 1). Roots elongation and growth was normal in the soil contaminated with Cd and Pb, with the exception of Pb 500 ppm.

For all three metals and for most of the pollution levels, the aerial part of the plants showed inhibition on the plant growth and restriction of the size of the leaves and the internodes. Chlorosis and necrosis of the leaves was observed in all four pollution levels of Cd and Ni. As the contamination level increased, the shoot biomass decreased with the exemption of the Pb 2500 ppm.

A significant increase of heavy metal accumulation in leaves was observed after 14 weeks as compared to the 10 weeks harvest.

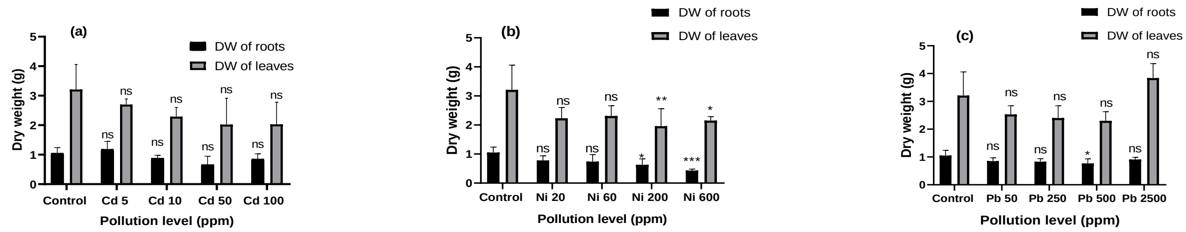

Figure 1. Dry mass of the leaves and roots. ns-not significant; * - P ≤ 0.05; ** - P ≤ 0.01; *** - P ≤ 0.00

The accumulation of Cd, Ni and Pb in the roots, leaves and flowers of *P. graveolens* at the end of the experiment, is presented in Table 1. For all metals, accumulation occurred mainly in the roots. Cd accumulated in the leaves only in the two highest levels. Plants grown in the presence of Ni and Pb translocated some metal in leaves. Metals in flowers were detected only in the case of Ni and the highest level of Pb.

Te major compounds in the essential oil in all the tested samples were: *β*-citronellol, trans-geraniol, citronellyl formate, 10-epi-*γ*-eudesmol, isomenthone, geranyl tiglate and geranyl butanoate. Other components were present in amounts less than 2%.

β-Citronellol appear to have the highest percentage in all the samples, with no significance difference in all four levels of Pb, but this compound showed an increase in percentage in the case of Cd 5 ppm, Cd 10 ppm, Ni 20 ppm and Ni 600 ppm,.

Trans-geraniol decreased in Ni 600, while in Cd 5 ppm and Cd 10 ppm this compound was not detected. For the other major compounds, the values in percentage were similar with the control sample.

4. Conclusions

Pelargonium graveolens L. grown in heavy metals polluted soils accumulates Cd, Ni and Pb mainly in the roots, depending on the level of contamination and at a lower amount in leaves. As Bioaccumulation and the Translocation Factors indicate, *P. graveolens* cannot be considered as a heavy metal accumulator.

The heavy metal pollution had relatively minor effects on the chemical composition of the essential oil of *P. graveolens,* mainly on *β*-Citronellol and trans-geraniol levels. The other major compounds were not affected by the heavy metal pollution.

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Table 2. Heavy metal uptake in the roots, leaves and flowers of *P. graveolens* grown in heavy metal-polluted soils

Added metal (ppm)	Roots (ppm)	Leaves (ppm)	Flowers (ppm)	BAF leaves	TF leaves
Cd					
0	0 ± 0.00	0 ± 0.00	0	0	0
5	18.27 ± 6.14	0 ± 0.00	0	0	0
10	26.26 ± 4.88	0 ± 0.00	0	0	0
50	89.69 ± 1.53	0.62 ± 0.87	0	0.01	0.01
100	187. 38 ± 78.33	0.94 ± 0.14	0	0.01	0.01
Ni					
0	1.04 ± 0.64	0.45 ± 0.13	0	1.18	0.43
20	13.70 ± 1.58	6.9 ± 1.71	6.77	0.64	0.5
60	59 ± 6.13	17.09 ± 0.33	14.59	0.57	0.29
200	140.04 ± 23.06	33.32 ± 4.77	29.02	0.27	0.24
600	94.04 ±20.45	54.01 ± 13.43	18.61	0.11	0.57
Pb					
0	2.22 ± 1.41	0.72 ± 1.01	0	0.12	0.32
50	0.72 ±1.02	0.53 ± 0.67	0	0.01	0.73
250	70.31 ±11.5	8.89 ± 2.59	0	0.04	0.13
500	236.08 ±20.05	18.30 ± 3.42	0	0.04	0.08
2500	5350.16 ±1390.36	85.96 ± 34.34	103.81	0.05	0.02