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Effect of Some Ornamental Plants for Phytoremediation of Contaminated Soil with Some Heavy Metals
I. *Vinca rosea* L.

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ABSTRACT
Phytoremediation considered as a process which uses green plants for the relief, transfer, stabilization, degradation of pollutants from soil. This research aimed to evaluate the effect of *Vinca rosea* L. from herbs, for phytoremediation of contaminated soil with heavy metals such as cadmium, lead, and copper. The used treatments were control, cadmium (1, 2, and 3 mg/L) in the form of cadmium acetate, lead (200, 400, and 600 mg/L) in the form of lead nitrate and copper (100, 200, and 300 mg/L) at form copper sulfate, on fresh biomass (g), the content of cadmium, lead and copper (mg/Kg) in different plant parts of *Vinca rosea* L. Results, showed that all treatments of cadmium, lead and copper significantly decreased fresh biomass compared to control in the two seasons respectively for leaves, stems and roots. On the other hand, all treatments of cadmium, lead and copper significantly increased the content of cadmium, copper for leaves, stems and roots compared to control in both seasons respectively. Data also cleared that, a significant increase in content of cadmium, lead, and copper in soil was obtained by all treatments of cadmium, lead, and copper compared to control in the two seasons.

Keywords: *Vinca rosea* L., cadmium, lead and copper, phytoremediation, fresh biomass, contaminated soil, content of cadmium, lead and copper in plant parts.

1. Introduction
Heavy metal contamination of agricultural soil is a complex and dangerous phenomenon that has serious consequences for the environment, as well as plants, humans, animals, and beneficial microorganisms, by affecting and staining food chains, soil, potable water or irrigation, groundwaters, and the surrounding atmosphere Wuana and Okieimen (2011). Cadmium (Cd) is a toxic metal that has no recognized biological function. Cadmium damages plants in a variety of ways, including disrupting metal homeostasis, which affects iron reduction in shoots Fodor *et al.,* (2005). Lead (Pb) accumulations in plant tissue, either directly or indirectly, disrupt a variety of physiological, biochemical, and morphological activities. Copper (Cu) is a vital and useful micronutrient that plays a role in plant physiological development Puig and Thiele (2002). Phytoremediation is a new technology that should be explored for contaminated site remediation because of its economic effectiveness, aesthetic benefits, and long-term applicability Cluis (2004), Vaziri *et al.,* (2013). In the same conditions, heavy metals accumulate at higher levels (more than 100 times) above ground than non-hyper accumulators' way of life, with no evident effects in their tissues Barcelo and Poschenrieder (2003). *Vinca rosea* L. (Periwinkle) is a species of the family Apocynaceae Loh (2008). It is annual evergreen, semishrub or herbaceous plant that grows up to one meter in height and secretes milky latex. The roots reach a depth of 70 cm. The plant's leaves are oval to oblong in shape. Flowers are pentamerous, ovate, and come in a variety of colors, including pink, rose-purple, blue, salmon, scarlet, and white, with a purple, red,

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pink, pale yellow, or white "eye" in the center and a mauve crown Nejat *et al.,* (2015). The plant and blooms are heat resistant, so they may grow in hot conditions Fuat (2006).

2. Materials and Methods

This research was conducted over two seasons (2019 and 2020) in a sunlight greenhouse with natural light, a day/night temperature of 30° C/22° C, and relative humidity of 50-70% of the Faculty of Agriculture (Saba Basha), Alexandria University, to investigate the influence of *Vinca rosea* L. with different concentrations of cadmium as cadmium acetate, lead (Pb) as lead nitrate and copper (Cu) as copper sulfate. The soil and plant samples used in this study obtained from a nursery on Alexandria's Government Highway. The soil was air-dried and then crushed with a hammer. The analyses of soil were described by Page *et al.,* (1982). The soil properties are shown in Table (a).

Table a: Mechanical and chemical properties of soil

Soil properties	First season	Second season
	Mechanical analysis	
Clay %	10.48	18.88
Silt %	10	38.00
Sand %	79.52	43.12
Soil texture	Loamy sand	Loam
pH	8.3	8.5
EC dS.m-1	0.92	1.3
Total CaCO3 (%)	21	21
Organic matter (%)	6.97	1.6
Field capacity (%)	22	37
	Soluble Cations and Anions (meq/L)	
Calcium	2.7	2.2
Magnesium	4.2	2.8
Sodium	2.1	1.16
Bicarbonate	3	3
Chloride	3.9	3.8
	Available macronutrients (meq/L)	
Nitrogen	20	30
Phosphorus	5.65	-
Potassium	0.19	0.3
	Extracted heavy metals (mg/Kg)	
DTPA-Cadmium	ND	ND
DTPA-Lead	0.91	0.65
DTPA-Copper	1.02	2.05
	Total heavy metals (mg/Kg)	
Total cadmium (Cd)	ND	ND
Total lead (Pb)	0.27	0.21
Total copper(Cu)	0.73	0.52

2.1. Treatments and design

The soil samples were divided into ten parts and mixed with heavy metals in the following order

- Control (without heavy metals)
- 1 mg of cadmium /kg soil (0.024 g Cd (CH_3COO) 2.2 H_2O/ kg soil)
- 2 mg of cadmium /kg soil (0.047 g Cd (CH_3COO) 2.2 H_2O/ kg soil)
- 3 mg of cadmium /kg soil (0.094 g Cd (CH_3COO) 2.2 H_2O/ kg soil)
- 200 mg of lead /kg soil (3.20 g Pb (NO_3) 2/kg soil)
- 400 mg of lead /kg soil (6.40 g Pb (NO_3) 2/kg soil)
- 600 mg of lead /kg soil (9.60 g Pb (NO_3) 2/kg soil)
- 100 mg of copper /kg soil (3.93 g Cu $SO_4.5H_2O$/ kg soil)
- 200 mg of copper /kg soil (7.86 g Cu $SO_4.5H_2O$ / kg soil)
- 300 mg of copper /kg soil (15.72 g Cu $SO_4.5H_2O$ / kg soil

The plants were in the stage of one-month seedlings with 15 cm height and all of them were healthy, in uniform size, and free of any disease symptoms, planted in pots (20 cm in diameter and 25 cm in height). All pots were filled with soil enriched with cadmium, lead, and copper with the previous concentrations, and then the pots were irrigated with tap water every day to keep the field capacity of soil at 70 %. The plants were harvested after ten months, then washed with tap water and separated into root, stem, and leaves.

Treatments were arranged in Randomized Complete Block Design (RCBD) Steel and Torrie (1980). Treatments were duplicated 3 times utilizing SAS Insti. (2002) statistical software on average.

2.3. Fresh biomass (g)

To determine the fresh biomass (g), roots, stems, and leaves of *Vinca rosea* L. were washed with tap water to remove any dust or suspended soil, then weighed separately, collected, and divided by their number to get the average.

2.4. Heavy metal concentrations in soil (mg/kg):

The available concentrations of cadmium (Cd), lead (Pb), and copper (Cu) were extracted using Lindsay and Norvell's (1978) with a 0.005 M diethylene triamine Penta acetic acid (DTPA) – 0.01 mol/l CaCl2 – 0.1 mol/l triethanolamine (Tea) solution (pH 7.30).

2.5. Total heavy metals in plant parts (mg/Kg)

The concentration of total heavy metals in plant parts (roots, stems, and leaves) was determined by Johnson and Ulrich's (1959) in a fine powdered dry matter of plant tissues. The total concentrations of cadmium (Cd), lead (Pb), and copper (Cu) in the sample solution were then measured using a Unicam Sp 1900 atomic absorption spectrophotometer Jackson (1967).

3. Results and Discussion

3.1. Fresh biomass (g)

The data in Table (1) indicate that all cadmium treatments significantly reduced the fresh biomass of leaves, stems and roots of *Vinca rosea* L. compared to control of both seasons respectively. The data also showed that the highest concentration (3 mg/L) of cadmium caused a significant decrease in fresh biomass (8.94, 6.68 and 10.23 g) and (9.61, 8.10 and 11.32 g) leaves, stems and roots during the first and second seasons, respectively, compared with the control (19.03, 11.54 and 16.44 g) and (19.86, 12.82 and 17.72 g) for leaves, stems and roots in the first and second seasons respectively. Das (2017) *Vinca rosea* L. grew up in pots with normal soil and irrigated with different cadmium concentrations in the form of cadmium chloride. Lower leaf senescence after a week, and growth returned to normal after 20 days, while biomass decreased after two months.

Results in Table (1) indicated that generally, lead treatments significantly decreased the fresh biomass compared to control in two seasons for leaves, stems, and roots of *Vinca rosea* L. except the lowest one (200mg/L) in the second season for stems (11.67g). The highest treatment (600 mg/L) significantly decreased fresh biomass for leaves, stems and roots (11.73, 7.43 and 9.72 g) and (12.53, 8.65 and 10.82 g) in the first and second seasons respectively, compared to control (19.03, 11.54 and 16.44 g) and (19.86, 12.82 and 17.72 g) for leaves, stems and roots in the first and second seasons respectively. Georgina wild L. was used as phytoremediator on contaminated soil with different levels of lead. The aerial parts of Georgina wild L. were found to be more tolerant of increasing lead levels in soil than the roots, and greater rates of lead in soil affected biomass and seed germination by Shivhare and Sharma (2012).

Copper treatments in Table (1) showed a significant decreased in fresh biomass for leaves, stems, and roots of *Vinca rosea* L. compared to control in both seasons except the lowest concentration (100 mg/L) in the second season for stems (11.58 g). The highest concentration (300 mg/L) significant decrease fresh biomass (12.50, 7.60 and 11.48 g) and (13.48, 8.21and 11.83 g) for leaves, stems and roots in the first and second seasons respectively, compared to control (19.03, 11.54 and 16.44 g) and (19.86, 12.82 and 17.72 g) for leaves, stems and roots in first and second seasons respectively. *Elsholtzia splendens* L. was used by Jiang et al., (2004) for phytoremediation of soil contaminated with various concentrations of copper. Plants could tolerate high copper concentrations in the soil up to 80 mg/kg.

3.2. Content of Cadmium, lead, and copper in plant parts

I. Cadmium content (mg/Kg)

The results in Table (2) cleared that, cadmium treatments significantly increased cadmium content compared to control in both seasons for leaves, stems, and roots of *Vinca rosea* L. except for treatment (1 mg/L) in the first season for leaves only (0.27 mg/Kg), and leaves and stems (0.43 and 0.37 mg/Kg) in the second season respectively. Data also showed that highest concentration (3mg/L) significant increase cadmium content of leaves, stems and roots (0.56, 0.89 and 2.53 mg/Kg) in first season and (0.86 and 3.79 mg/Kg) for leaves and roots respectively in second seasons compared to control (0.04, 0.05 and 0.02 mg/Kg) for leaves, stems and roots in the first and second seasons respectively, while the intermediate concentration (2 mg/L) was highest cadmium content for stems (1.37 mg/Kg) in second season only. Bosiacki (2008) employed varied cadmium doses on *Tagetes erecta* L., *Salvia splendens* L., and *Helianthus annuus* L. The largest concentrations of cadmium were identified in *Tagetes erecta* L. roots, *Salvia splendens* L. leaves and branches, and *Helianthus annuus* L. inflorescences, according to the findings. As a result of the prior findings, it was determined that *Tagetes erecta* L. had the greatest cadmium concentration.

As for, data in Table (2) indicated that generally, all lead treatments significantly increased the cadmium content of leaves, stems, and roots of *Vinca rosea* L. compared to control in the two seasons. Data also cleared that the highest treatment (600 mg/L) significant increase cadmium content (2.64, 3.22 and 6.83 mg/Kg) and (2.92, 3.71 and 7.20 mg/Kg) for leaves, stems and roots respectively compared to control (0.04, 0.05 and 0.02 mg/Kg) in both seasons for leaves, stems and roots respectively. Rising lead concentrations inhibited germination of *Vinca rosea* L. seeds affected by various doses of lead chloride solutions, the decrease in amylase and protease enzymes in seeds was the reason for this according to Pandey *et al.,* (2007).

Concerning copper treatments in Table (2) showed that all treatments significantly increased cadmium content compared to control in the two seasons for leaves, stems, and roots of *Vinca rosea* L. The highest concentration (300 mg/L) significant increase cadmium content for leaves, stems and roots (1.76, 4.21 and 5.15 mg/Kg) and (1.51,4.67 and 5.81 mg/Kg) respectively in the first and second seasons compared to control (0.04, 0.05 and 0.02 mg/Kg) for leaves, stems and roots respectively in both seasons. According to Shubhangi and Sharma (2015), excessive copper concentrations reduced the length of *Calendula officinalis* L. roots and shoots compared to control.

II. Lead content (mg/Kg)

The results in Table (3) showed that, cadmium treatments did not affect significantly on lead content compared to control in the two seasons for stems and roots only of *Vinca rosea* L., except the highest treatment (3 mg/L) for roots (0.30 mg/Kg) in the first season compared to control. The highest treatment (3 mg/L) significantly increased lead content for leaves, stems and roots (0.22, 0.09 and 0.30 mg/Kg) and (0.37, 0.06 and 1.16 mg/Kg) respectively in the first and second seasons compared to control (0.04, 0.05 and 0.07 mg/Kg) and (0.01, 0.06 and 0.06 mg/Kg) for leaves, stems and roots in the first and second seasons respectively. Various concentrations of lead were put into the potting soil of zinnia and marigold plants, although plant lead levels were discovered to be high, zinnia plants were shown to be more resistant to lead than marigold plants by Thamayanthi *et al.,* (2013).

Table (3), revealed that a significant increase in lead content was obtained by all treatments of lead compared to control in both seasons for *Vinca rosea* L. leaves, stems, and roots. Data showed that the highest concentration (600 mg/L) significant increase lead content (3.95, 1.99 and 6.23 mg/Kg) and (4.04, 2.16 and 6.91 mg/Kg) for leaves, stems and roots in the first and second seasons respectively, compared to control (0.04, 0.05 and 0.07 mg/Kg) and (0.01, 0.06 and 0.06 mg/Kg) for leaves, stems and roots in the first and second seasons respectively. Bosiacki *et al.,* (2013) Plants of the *Amaranthus caudatus* L. species were cultivated in soil contaminated with various levels of lead. Lead concentrations were found to be higher in leaves and lower in the inflorescences. As a result, phytoextraction could be used to extract lead from the soil using the *Amaranthus caudatus* L. plant.

Table (3) declares that copper treatments significantly increased lead content compared to control in the two seasons for leaves, stems, and roots of *Vinca rosea* L. except for (100mg/L) treatment in the second season for roots (0.92 mg/Kg). Data also cleared that the highest treatment (300 mg/L) significant increase lead content for leaves, stems and roots (1.50, 0.73 and 1.07 mg/Kg) and (1.67, 0.91 and 2.65 mg/Kg) respectively in the first and second seasons compared to control (0.04, 0.05 and 0.07

mg/Kg) and (0.01, 0.06 and 0.06 mg/Kg) for leaves, stems and roots in the first and second seasons respectively. Afrousheh *et al.,* (2015) *Calendula officinalis* L. roots and shoots grew slower when exposed to increased copper concentrations. Roots accumulated the least copper, whereas shoots accumulated the most.

III. Copper content (mg/Kg)

As for cadmium treatments in Table (4) cleared that, significantly increased the copper content for stems and roots of *Vinca rosea* L. compared to control in both seasons. Data showed that the highest concentration (3 mg/L) significant increase copper content for leaves, stems and roots (0.28, 0.33 and 0.85 mg/Kg) and (0.35, 0.40 and 0.96 mg/Kg) in the first and second seasons respectively compared to control (0.05, 0.05 and 0.17 mg/Kg) for leaves, stems and roots respectively in both seasons. Growing sunflower plants in soil contaminated with different concentrations of cadmium resulted in cadmium accumulation in the roots, which stimulated low levels of membrane leakage, lipid peroxidation, and photosynthesis, indicating that sunflower plants can remediate cadmium-contaminated soil Sewalem *et al.,* (2014).

Likewise, data in Table (4) showed that lead content significantly increased copper content compared to control in the two seasons for the stems and roots of *Vinca rosea* L. except high concentration (600 mg/L) for leaves (0.43 mg/Kg) in the first season only. The highest concentration (600 mg/L) significantly increased copper content of leaves, stems and roots (0.43, 0.70 and 0.56 mg/Kg) and (0.50, 0.79 and 0.70 mg/Kg) respectively in the first and the second seasons compared to control (0.05, 0.05 and 0.17 mg/Kg) in both seasons for leaves, stems and roots respectively. Sewalem *et al.,* (2014) examined a sunflower plant that was cultivated in soil contaminated with different levels of lead, showed that significant concentrations of lead had accumulated in the vegetative part of the plant, affecting their growth. As a result, the sunflower plant is both an accumulator and a remediator for lead-contaminated soil.

As for copper treatments in Table (4) significantly increased copper content in leaves, stems, and roots of *Vinca rosea* L. in both seasons compared to control. The high concentration (300 mg/L) significant increase copper content (4.60, 1.78 and 5.06 mg/Kg) and (4.83, 1.83 and 5.91 mg/Kg) for leaves, stems and roots in the first and second seasons respectively, compared to control (0.05, 0.05 and 0.17 mg/Kg) in both seasons for leaves, stems and roots respectively. Rajakumar and Ramamurthy (2016) cleared that the most effective plant height and fresh weight of *Brassica junecea* L. was grown in copper-contaminated soil was obtained during the 8th week of the experiment.

3.3. Available heavy metals content in soil (mg/Kg)

Table (5) showed that cadmium treatments of *Vinca rosea* L. significantly increased the content of cadmium, lead, and copper in soil compared to control in the two seasons, except for lead content, respectively in the first season, and the intermediate concentration (2mg/L) for copper content in the second season. Data observed that the highest concentration (3 mg/L) significantly increased the content of cadmium and lead in soil (0.99 and 1.48 mg/Kg) respectively in the first season and content of cadmium, lead, and copper in soil (1.18, 1.74 and 0.68 mg/Kg) in the second season respectively, compared to control (0.02, 0.04 and 0.00 mg/Kg) and (0.02, 0.03 and 0.03 mg/Kg) respectively for cadmium, lead, and copper content in soil in the first and second seasons. The lowest concentration (1 mg/L) significant increase copper content (0.59 mg/Kg) in the first season compared to control (0.00 mg/Kg) and compared to highest one (3mg/L) was (0.47 mg/Kg). Bradl (2004) discovered that cadmium metal mobility is greatest in the pH range of 4.5 to 5.5, and is slow a pH of more than 7.5. Cadmium compounds precipitate in alkaline soils, and the form Cd^{2+} is precipitated in high cadmium concentrations in general.

Lead treatments in Table (5) cleared that, significantly increased in cadmium, lead, and copper content in soil compared to control in both seasons for *Vinca rosea* L. Data also cleared that the highest one (600 mg/L) significant increase cadmium and copper content in soil (1.93 and 2.22 mg/Kg) respectively in the first season and (2.16, 4.99 and 2.02 mg/Kg) for cadmium, lead and copper in the second season respectively, compared to control (0.02, 0.04 and 0.00 mg/Kg) and (0.02, 0.03 and 0.03 mg/Kg) respectively for cadmium, lead, and copper content in soil in the first and second seasons. The lowest one (200 mg/L) significant increase lead content (3.45 mg/Kg) in first season compared to control (0.04 mg/Kg) and compared to the highest one (600 mg/L) was (3.27 mg/Kg). In soil, Pb^{2+} can

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Table 1: The effect of cadmium, lead and copper on fresh biomass (g) of *Vinca rosea* L. of leaves, stems and roots in first season (2019) and second season (2020).

Fresh biomass in plant parts (g)	Control	Cadmium 1 mg/L	Cadmium 2 mg/L	Cadmium 3 mg/L	Lead 200 mg/L	Lead 400 mg/L	Lead 600 mg/L	Copper 100 mg/L	Copper 200 mg/L	Copper 300 mg/L	L.S.D $_{0.05}$
First season (2019)											
Leaves	19.03a	11.68f	10.65g	8.94h	13.54c	12.46ed	11.73ef	15.77b	13.67C	12.50d	**0.75**
Stems	11.54a	9.74c	7.49ef	6.68f	10.59b	9.93bc	7.43ef	10.56bc	8.50D	7.60e	**0.83**
Roots	16.44a	12.29d	10.87f	10.23gh	13.13c	10.47fg	9.72h	14.37b	12.29D	11.48e	**0.52**
Second season (2020)											
Leaves	19.86a	12.40ef	11.53f	9.61g	14.50c	13.39d	12.53de	17.14b	14.52c	13.48d	**0.98**
Stems	12.82a	10.69bc	8.81d	8.10d	11.67ab	10.49bc	8.65d	11.58ab	9.35cd	8.21d	**1.38**
Roots	17.72a	12.74d	12.93d	11.32ef	14.25c	11.81e	10.82f	15.58b	13.40cd	11.83e	**0.87**

Means followed by a similar letter within a column are not significantly different at 0.05 level probability by least significant difference Test P<0.05

Table 2: The effect of cadmium, lead and copper on cadmium content (mg/Kg) of *Vinca rosea* L. of leaves, stems and roots in first season (2019) and second season (2020).

Plant parts	Control	Cadmium 1 mg/L	Cadmium 2 mg/L	Cadmium 3 mg/L	Lead 200 mg/L	Lead 400 mg/L	Lead 600 mg/L	Copper 100 mg/L	Copper 200 mg/L	Copper 300 mg/L	L.S.D$_{0.05}$
First season (2019)											
Leaves	0.04g	0.27fg	0.32ef	0.56de	0.99c	1.50b	2.64a	0.58d	0.95c	1.76b	**0.26**
Stems	0.05i	0.28h	0.66g	0.89f	2.53c	1.89e	3.22b	1.76e	2.25d	4.21a	**0.14**
Roots	0.02h	0.90g	1.52f	2.53e	0.78g	2.93d	6.83a	0.97g	3.72c	5.15b	**0.19**
Second season (2020)											
Leaves	0.04f	0.43ef	0.69de	0.86de	1.15cd	1.80b	2.92a	0.81de	1.06cd	1.51bc	**0.48**
Stems	0.05f	0.37f	1.37e	1.00e	2.84c	2.04d	3.71b	1.93d	2.71c	4.67a	**0.56**
Roots	0.02g	1.01f	1.88e	3.79c	0.93f	3.33d	7.20a	1.14f	4.12c	5.81b	**0.37**

Means followed by a similar letter within a column are not significantly different at 0.05 level probability, by least significant difference Test P<0.05

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Table 3: The effect of cadmium, lead and copper on lead content (mg/Kg) of *Vinca rosea* L. of leaves, stems and roots in first season (2019) and second season (2020).

Plant parts	Treatments										L.S.D$_{0.05}$
	Control	Cadmium			Lead			Copper			
		1 mg/L	2 mg/L	3 mg/L	200 mg/L	400 mg/L	600 mg/L	100 mg/L	200 mg/L	300 mg/L	
	First season										
Leaves	0.04h	0.14g	0.18fg	0.22fg	0.90d	1.76b	3.95a	0.24f	0.80e	1.50c	**0.09**
Stems	0.05e	0.04e	0.08e	0.09e	1.02b	1.07b	1.99a	0.29d	0.55C	0.73c	**0.23**
Roots	0.07g	0.07g	0.13g	0.30f	2.89c	4.75b	6.23a	0.33f	0.76e	1.07d	**0.10**
	Second season										
Leaves	0.01h	0.13g	0.26f	0.37e	0.99d	1.85b	4.04a	0.35ef	0.90d	1.67c	**0.10**
Stems	0.06f	0.00f	0.03f	0.06f	1.15bc	1.43b	2.16a	0.45e	0.67De	0.91cd	**0.31**
Roots	0.06f	0.37ef	1.07def	1.16def	3.18c	5.09b	6.91a	0.92ef	1.77cde	2.65cd	**1.59**

Means followed by a similar letter within a column are not significantly different at 0.05 level probability, by least significant difference Test P<0.05

Table 4: The effect of cadmium, lead and copper on copper content (mg/Kg) of *Vinca rosea* L. of leaves, stems and roots in the first season (2019) and the second season (2020).

Plant parts	Treatments										L.S.D$_{0.05}$
	Control	Cadmium			Lead			Copper			
		1 mg/L	2 mg/L	3 mg/L	200 mg/L	400 mg/L	600 mg/L	100 mg/L	200 mg/L	300 mg/L	
	First season										
Leaves	0.05 e	0.19 de	0.35de	0.28de	0.14de	0.26de	0.43d	0.84c	2.32b	4.60a	**0.31**
Stems	0.05g	0.26ef	0.23f	0.33de	0.25ef	0.52c	0.70b	0.42d	0.77b	1.78a	**0.10**
Roots	0.17i	0.34g	0.60e	0.85d	0.43f	0.26h	0.56e	1.72c	3.21b	5.06a	**0.04**
	Second season										
Leaves	0.05c	0.24c	0.40c	0.35c	0.19c	0.31c	0.50c	1.72b	2.05b	4.83a	**0.49**
Stems	0.05g	0.17f	0.30e	0.40d	0.30e	0.57c	0.79b	0.45d	0.87b	1.83a	**0.09**
Roots	0.17h	0.49fg	0.72e	0.96d	0.60ef	0.38g	0.70e	1.91c	3.90b	5.91a	**0.15**

Means followed by a similar letter within a column are not significantly different at 0.05 level probability, by least significant difference Test P<0.05

Table 5: The effect of cadmium, lead and copper on cadmium, lead and copper content (mg/Kg) in soil of *Vinca rosea* L. of leaves, stems and roots in the first season (2019) and the second season (2020).

Content of heavy metal in soil (mg/Kg)	Treatments										L.S.D$_{0.05}$
	Control	Cadmium			Lead			Copper			
		1 mg/L	2 mg/L	3 mg/L	200 mg/L	400 mg/L	600 mg/L	100 mg/L	200 mg/L	300 mg/L	
First season											
Cadmium	0.02h	0.73g	0.87f	0.99e	0.76fg	1.02e	1.93c	1.61d	2.25b	2.67a	**0.11**
Lead	0.04f	0.77ef	1.06ef	1.48ef	3.45c	2.34cde	3.27cd	5.50ab	5.49b	7.43a	**1.93**
Copper	0.00j	0.59g	0.37i	0.47h	1.28f	1.68e	2.22c	1.82d	6.47b	10.55a	**0.09**
Second season											
Cadmium	0.02d	0.84c	1.01c	1.18c	0.92c	1.22c	2.16ab	1.87b	2.38a	2.25ab	**0.48**
Lead	0.03h	0.92g	1.39fg	1.74ef	3.27c	3.18cd	4.99b	2.45de	3.89c	7.43a	**0.76**
Copper	0.03h	0.48fg	0.31gh	0.68f	0.70f	1.46e	2.02d	2.39c	8.55b	11.33a	**0.30**

Means followed by a similar letter within a column are not significantly different at 0.05 level probability, by least significant difference Test $P<0.05$

be electrostatically absorbed by negatively charged soil constituents (clay and metal hydroxides), then replaced by soil cations and returned to the soil solution, increasing its availability and toxicity. Lead mobility is limited in general, but it increases when the pH is lowered, so keep that in mind Kabata-Pendias (2010).

The results in Table (5) cleared that, copper treatments significantly increased cadmium, lead, and copper content in soil compared to control in the two seasons for *Vinca rosea* L. Data also revealed that the high treatment (300 mg/L) significantly decreased cadmium, lead and copper content in soil (2.67, 7.43 and 10.55 mg/Kg) respectively in the first season and (7.43 and 11.33 mg/Kg) respectively for lead and copper content in the second season compared to control (0.02, 0.04 and 0.00 mg/Kg) and (0.02, 0.03 and 0.03 mg/Kg) respectively for cadmium, lead, and copper content in soil in the first and second seasons. The intermediate concentration (200 mg/L) significant increase cadmium content (2.38 mg/Kg) in second season compared to control (0.02 mg/Kg) and compared to the highest one (300 mg/L) was (2.25 mg/Kg). Hou *et al.,* (2007) observed that copper toxicity and interaction with the biological movement of other elements such as phosphorus, zinc, and iron due to the very high levels of copper in the soil.

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