Egyptian Journal of Agricultural Research

ORIGINAL ARTICLE Egypt. J. Agric. Res., (2020), 98 (4), 645-652

To what extent can Rose of China (*Hibiscus rosa-sinensis*, L.) transplants tolerate toxicity of some heavy metals in combinations?

Sayed M. Shahin*, Ahmed M.A Mahmoud and Reem M. Said
Horticulture Research Institute, Agricultural Research Center, Egypt
*sayedshaheen551@gmail.com

(Manuscript received October 2020) 10.21608/ejar.2021.46655.1032

ABSTRACT

A study was conducted at Orman Botanical Garden, Giza, Egypt during 2018 and 2019 seasons to detect the effect of Pb, Cd, and Ni heavy metals in combinations on growth and flowering of *Hibiscus rosa-sinensis*, L. ornamental plant. Concentrations of Pb + Cd + Ni were 00.00 ppm for control, 500 + 50 + 25 ppm for combination number one (T1) and twice, thrice and four-fold of these concentrations for combinations number two (T2), three (T3) and four (T4), respectively. Results indicated that no mortality was observed among the elemental-polluted plants, although the means of their various vegetative and root growth parameters were progressively decreased with increasing heavy metals concentrations in most cases of both seasons. Thus, the shortest and smallest plants were attained by T4 combination, followed by T3 one. The pollution resistance index (PRI%), was gradually decreased with increasing heavy metals concentrations to be more than 80% in both seasons, even by T4 treatment, pointing to the high ability of such plant to encounter the hazards of toxic metals. Means of flower diameter, flower fresh weight, and concentrations of chlorophyll a, carotenoids, and total soluble sugars were decreased, but flower axil length and concentrations of K in the leaves, as well as Pb, Cd and Ni in the leaves and roots, were progressively increased as a result of the gradual increment of heavy metals, with few exceptions in both seasons.

Accordingly, *H. rosa-sinensis* plant can be successively used for landscaping of sites polluted with high concentrations of heavy metals.

Keywords: Rose of China (*Hibiscus rosa-sinensis*, L.), soil pollution, heavy metals, PRI.

INTRODUCTION

The tolerance power of ornamental plants for growing well in soil polluted with heavy metals differs from one species to another. So, determining the potential of each species to toxicity of these hazardous metals may be urgent for detecting an active and greatly cheap way for removing such pollutants from the soil or rendering them harmless through using such ornamentals, which are considered non-food chain plants (Tauqeer *et al.*, 2016). Among these ornamentals, valid for this purpose may be Rose of China (*Hibiscus rosa-sinensis*, L.) that belongs to Fam. Malvaceae. It is a large beautiful evergreen shrub to 5-7 m height, nearly glabrous; leaves usually simple, ovate, toothed or nearly entire; grown mostly in subtropical and tropical regions for its profuse large very showy flowers that are born solitary on the leaf axils, and also in glasshouses for the summer bloom (Bailey, 1976). Some medicinal uses of *H. rosa-sinensis* were reported by Jadhav *et al.* (2009) who mentioned that over 100 million women worldwide are using *H. rosa-sinensis* with contraceptives to suppress fertility at will, for as long as desired, with almost 100% confidence and complete return to fertility on discontinuation. It is also used for regulation of the menstrual cycle, diuretic, anti-tussive, dysentery, amenorrhea, and abortion.

Furthermore, *H. rosa-sinensis* is the most significant and appealing species of genus Hibiscus, with a wide range of cultivars grown across the globe (Khan *et al*, 2014). It is a potential source of many bioactive natural products, which are of significant value in folk medicinal system, especially for curing liver disorders and hypertension (Yasmin, 2010). Many reports, however, exhibited that Hibiscus species are effective for metal uptake and can be fitted in long-term phytoremediation programs for removal of toxicants (Bhaduri and Fulekar, 2015). In this respect, Rai *et al.* (2013) found that the highest relative water content (RWC) in the industrial site was seen in *Hibiscus rosa-sinensis* compared to control site, whereas pH of leaf extract was reduced, and that makes such plant able to encounter air pollution stress. On the same line, were those results of Noman *et al* (2017), Shrivastava and Prakash (2017), and Safari *et al* (2018) on *H. rosa-sinensis*.

The deleterious effects of heavy metals on ornamental plants were previously documented by Shahin *et al*. (2002) on *Salvia splendens* and *Vinca rosea* cvs. Alba and Major, Wang and Zhou (2005) on *Tagetes erecta*, *Salvia splendens* and *Abelmoschus manihot*, Shahin *et al*. (2007) on *Matthiola incana* and *Dimorphotheca ecklonis*. Manousaki and Kalogerakis (2009) on *Atriplex halimus*, Erdogan *et al*. (2011) on *Aptenia cordifolia*, Wang *et al*. (2012) on *chlorophytum comosum*, Ramana *et al*. (2015) on *Euphorbia milli*, Ehsan *et al*. (2016) on *Vinca rosea*, Forte and Mutiti (2017) on *Helianthus annus* and *Hydrangea paniculata* and Omar (2018) who found that *Sambucus nigra* transplants can tolerate toxicity of Pb, Cd and Ni up to 2000, 200 and 100 ppm concentrations for the three metals, respectively plus uptaking considerable amounts of such metals indicating its ability for purifying the environment from them, while *Bauhinia purpurea* ones can tolerate toxicity of these metals, only up to 1000, 100 and 50 ppm concentrations pointing their low validity for environmental cleaning.

The purpose of this trial, however, is to discover the potential of Chinese hibiscus to tolerate toxicity of lead, cadmium, and nickel when applied together in gradual concentrations

MATERIALS AND METHODS

This investigation was carried out in the open field at Orman Botanical Garden, Giza, Egypt throughout 2018 and 2019 seasons to explore the impact of lead (Pb), cadmium (Cd), and nickel (Ni) at various concentrations on survival, growth and chemical composition of Chinese hibiscus transplants when applied in combinations.

So, the young uniform transplants of *Hibiscus rosa-sinensis*, L. (6-months-old at about 22-23 cm length with 10-12 leaves) were planted on April, 1st for every season in 20-cm-diameter black polyethylene bags (one transplant/bag) filled with about 4 kg of sand and clay mixture at equal parts by volume (1:1, v/v). The physical and chemical properties of the sand and clay soil used in the two seasons were determined and shown in Table (a).

Table (a): The physical and chemical properties of the sand and clay soil used in 2018 and 2019 seasons.

Soil type	season	Particle size distribution (%)				S.P	E.C (ds/m)	pH	Cations (meq/l)				Anions (meq/l)		
		Coarse sand	Fine sand	silt	clay				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}
Sand	2018	18.72	71.28	4.76	5.34	21.83	1.58	8.20	2.65	2.48	21.87	0.78	3.85	13.00	10.93
	2019	79.76	9.30	2.50	8.44	23.10	1.76	7.90	19.42	8.33	7.20	0.75	1.60	7.80	26.30
Clay	2018	7.46	16.75	34.53	40.89	41.67	2.10	8.33	16.93	9.33	20.44	0.37	3.82	1.46	41.79
	2019	7.64	22.50	30.15	39.71	53.36	2.23	7.92	7.50	2.21	15.49	0.75	6.28	8.12	11.05

Easy and quick soluble-salts (acetates) of lead [$Pb\ (CH_3CO_2)_2$], cadmium [$Cd\ (CH_3CO_2)_2$] and nickel [$Ni\ (CH_3CO_2)_2$] produced by Aldrich Chemical Co., Inc., 1001, West Saint Paul Avenue, Milwaukee, Wisconsin 53233, USA were mixed well in combinations through the particles of the used soil mixture before filling the plastic bags at the following concentrations:

- 00.00 ppm for each metal, as control.
- 500 ppm Pb + 50 ppm Cd + 25 ppm Ni for T1.
- 1000 ppm Pb + 100 ppm Cd + 50 ppm Ni for T2.
- 1500 ppm Pb + 150 ppm Cd + 75 ppm Ni for T3.
- 2000 ppm Pb + 200 ppm Cd + 100 ppm Ni for T4.

The plastic bags (without drain holes to keep the metals from leaching) were immediately irrigated after planting with 350 ml of freshwater/bag, but afterwards the irrigation was done day by day with only 250 ml of water/bag till the end of the experiment. However, the other usual agricultural practices needed for this plantation were carried out in time. The layout of the experiment in both seasons was a complete randomized design, replicated thrice with five plants per replicate (Mead *et al*., 1993).

At the end of each season (on October, 1st), data were recorded as follows: survival (%), plant height (cm.), stem diameter at the base (cm.), number of branches and leaves/plant, leaf area (cm^2), petiole length (cm.), root length (cm.), number of roots/ plant, as well as aerial parts and roots fresh and dry weights (g.). Besides, the pollution resistance index as a percent (PRI%) was calculated from the equation of Wilkins (1957):

PRI(%): Mean root length of the polluted plant/ mean root length of control one ×100

During flowering, the first flower diameter (cm.) and its axil length (cm.), fresh and dry weights (g) were measured.

In fresh leaf samples taken from the middle part of the plants, photosynthetic pigments (chlorophyll a, b and carotenoids, mg/g.f.w.) and total soluble sugars (mg/g. f.w.) were determined by the methods of Sumanta (2014) and Dubois *et al.*(1966), respectively, while in dry ones, the percentages of nitrogen (Black, 1956), phosphorus (Cottenie *et al*., 1982) and potassium (Page *et al*., 1982) were assessed. Moreover, the concentration of Pb, Cd, and Ni as ppm was evaluated in dry samples of leaves and roots according to the methods described by Page *et al*. (1982). All chemical analysis were only measured in the second season.

Data were then tabulated and the morphological ones were subjected to analysis of variance using a program of SAS Institute (2009), which was followed by Duncan's New Multiple Range Test (Steel and Torrie, 1980) for comparison of means.

RESULTS AND DISCUSSION

Effect of lead (Pb), cadmium (Cd), and nickel (Ni) combinations on:

1. Survival percentage and vegetative and root growth parameters:

Data in Tables (1,2 and 3) clear that the survival % of Hibiscus plants subjected to heavy metals stress was 100% as control, without death in both seasons, although means of various vegetative and root growth characters were gradually decreased with increasing concentrations of these metals in most cases of the two seasons. Therefore, the least records of plant height (cm.), stem diameter (cm.), No. branches and leaves/ plant, leaf area (cm^2), petiole length (cm.), root length (cm.), No. roots/plant, as well as fresh and dry weights of aerial parts and roots (g) were attained by T4 combination and followed by T3 one. This may be ascribed to the higher accumulation of toxic metals in plant tissues (as shown in Table 6), which usually reduces activity of most vital processes, such as photosynthesis, inhibits activity of some enzymatic systems and prevents the formation of carbohydrates, proteins and other metabolites (Rai *et al.*, 2013). The organic Pb was found to derange the spindle fiber mechanism of cell division in plants, while Cd and Ni were found to reduce glutathione reductase activity (Omar, 2018).

In this regard, Manousaki and Kalegorakis (2009) found that Cd and Pb greatly reduced growth and biomass and changed water relations in *Atriplex halimus* plants. Ramana *et al.* (2015) revealed that Cr at concentrations more than 75 ppm markedly reduced growth and survival% of *Euphorbia millii* plants. Further, Ehsan *et al.* (2016) noticed that plant height, No. leaves/ plant, fresh and dry weights of *Vinca rosea* plants were improved at low concentrations of Cr (10-30 ppm), but decreased at high ones (40-60 ppm).

The percent of pollution resistance index (PRI%), as a real index denotes the capability of a plant to encounter pollution stress, was 100% for control plants in the two seasons (Table, 2), but it was significantly decreased consecutively to be more than 80%, even by the highest concentrations of toxic metals (T4 combination), indicating the ability of *H. rosa-sinensis* plants to combat toxicity of Pb, Cd and Ni metals when applied together at high concentrations. This may be attributed to either ability of hibiscus species to keep the relative water content in their leaves to the highest level plus reducing leaf extract pH to minimum value at polluted area (Rai et al., 2013), or inducing histological changes in their organs, such as those revealed by Noman *et al.* (2017) who observed that presence of toxicants in the rhizosphere modified anatomical features in *H. rosa-sinensis* cvs. Cooperi alba and Lemon chiffon, like thick stem epidermis, increased epidermal cell area, high vascular tissue, and enhanced cortical cell area. Likewise, Shrivastava and Prakash (2017) indicated that a marked alternation in epidermal traits, with an increased number of stomata and epidermal cells per unit area in leaf samples of *H. rosa-sinensis* plant collected from polluted sites than those from control ones. The length and width of guard cells and epidermal cells reduced significantly in leaves of polluted sites. In this concern, Safari *et al.* (2018) declared that the maximum accumulation index of Ni, Pb, V, and Co metals were found in the leaves of *Nerium oleander* (1.58) and in bark of *H. rosa-sinensis* (1.95) plants grown in industrial and urban areas than that of control site. So, hibiscus plants are effective for metal uptake and can be fitted in long-term phytoremediation programs for removal of toxicants (Bhaduri and Fulekar, 2015).

Table (1): Effect of heavy metals combinations on survival and some vegetative growth traits of *Hibiscus rosa-sinensis*, L.plants during 2018 and 2019 seasons.

Heavy metals combinations (Pb+Cd+Ni,ppm)	Survival (%)		Plant height (cm)		Stem diameter (cm)		No. branches/ plant		No.leaves/ plant	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
0.0+0.0+0.0 (Cont.)	100.00	100.00	67.33a	64.78a	0.85a	0.88a	3.00a	3.00a	42.33a	41.00a
500+50+25 (T1)	100.00	100.00	68.00a	65.10a	0.76b	0.75b	2.66a	2.38ab	39.50ab	35.92b
1000+100+50 (T2)	100.00	100.00	65.93ab	64.27a	0.73b	0.76b	2.00b	2.00b	33.00b	31.76c
1500+150+75 (T3)	100.00	100.00	56.00b	53.50b	0.84a	0.83a	2.00b	2.00b	28.17c	27.00d
2000+200+100 (T4)	100.00n.s.	100.00 n.s.	43.50c	43.00c	0.55c	0.51c	1.33c	1.31c	25.00d	23.78e

Means followed by the same letter in a column do not differ significantly according to Duncan's New Multiple Range t-Test at P=0.05.

Table (2): Effect of heavy metals combinations on leaf area, petiole length, root length, No. roots/plant, and PRI of *Hibiscus rosa-sinensis*, L. plants during 2018 and 2019 seasons.

Heavy metals combinations (Pb+Cd+Ni,ppm)	Leaf area (cm^2)		Petiole length (cm)		Root length (cm)		No. roots/ plant		Pollution resistance index (PRI%)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
0.0+0.0+0.0 (Cont.)	36.96b	37.58a	3.87a	3.59a	49.31a	46.50a	8.00a	7.33a	100.00a	100.00a
500+50+25 (T1)	41.32a	40.10a	3.43a	3.47a	43.90b	43.17b	6.67b	7.00a	89.03b	92.84b
1000+100+50 (T2)	39.37a	38.21a	3.33a	3.38a	45.10b	42.33b	6.50b	6.33b	91.46b	91.03b
1500+150+75 (T3)	30.81c	30.10b	3.25a	3.26a	43.76b	40.16bc	6.71b	6.30b	88.75b	86.37bc
2000+200+100 (T4)	26.34d	25.71c	2.50b	2.53b	40.21c	39.00c	5.33c	5.15c	81.55c	83.87c

Means followed by the same letter in a column do not differ significantly according to Duncan's New Multiple Range t-Test at P=0.05.

Table (3): Effect of heavy metals combinations on aerial parts and roots fresh and dry weights of *Hibiscus rosa-sinensis*, L. plants during 2018 and 2019 seasons.

Heavy metals combinations (Pb+Cd+Ni,ppm)	Aerial parts				Roots			
	Fresh weight (g)		Dry weight (g)		Fresh weight (g)		Dry weight (g)	
	2018	2019	2018	2019	2018	2019	2018	2019
0.0+0.0+0.0 (Cont.)	56.48a	54.80a	21.07a	20.43a	18.25a	17.51a	8.20a	7.87a
500+50+25 (T1)	49.39b	48.46b	19.73b	19.31b	17.80ab	17.10ab	7.89a	7.58a
1000+100+50 (T2)	47.38c	45.91c	17.64c	17.11c	17.33b	16.64b	6.93b	6.49b
1500+150+75 (T3)	45.76d	43.32d	15.38d	14.50d	15.87c	15.23c	6.50b	6.24b
2000+200+100 (T4)	36.73e	35.39e	13.45e	12.97e	15.36c	14.38d	5.78c	5.31c

Means followed by the same letter in a column do not differ significantly according to Duncan's New Multipte Range t-Test at P=0.05.

2. Flowering characteristics:

It is obvious from data averaged in Table (4) that flower diameter (cm.) and flower fresh weight (g) are the most flowering traits negatively affected by toxicity of heavy metals combinations employed in such work, as their means consecutively decreased as the concentrations of heavy metals were increased, with few exceptions in both seasons. On the other hand, means of flower axil length (cm.) were significantly increased over control means by the various used treatments without significant differences among themselves in the two seasons. Yet, flower dry weight (g) was not affected by treatments of this trial, as the values of such traits were closely near together in both seasons.

The deleterious effect of heavy metals on some flowering criteria may be referred to a reduction in cytokinin and gibberellin activities and sucrose and glucose contents in bud meristems during the transition to flowering (Bessonova, 1993). In this connection, Shahin *et al.* (2007) decided that flower diameter, No. inflorescences, and No. florets were descendingly decreased in plants of *Matthiola incana* and *Dimorphotheca ecklonis* with increasing Pb, Cd, and Ni concentrations. ZhiGuo and Wang (2013) recorded that the fresh weight of 100 flowers of some marigold cultivars was progressively declined with the increase of Cd concentration. Similarly, Eid *et al*. (2016) observed that Cd at 80 ppm level significantly decreased No. flowers and flower dry weight of *Tagetes erecta* plants.

Table (4): Effect of heavy metals combinations on flowering characteristics of *Hibiscus rosa-sinensis*, L. plants during 2018 and 2019 seasons.

Heavy metals combinations (Pb+Cd+Ni,ppm)	**Flower diameter (cm)**		**Flower axil length (cm)**		**Flower f.w. (g)**		**Flower d.W. (g)**	
	2018	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
0.0+0.0+0.0 (Cont.)	10.31a	10.09a	6.25b	6.07b	3.47a	3.51a	2.11	2.09
500+50+25 (T1)	7.62b	7.45b	9.71a	9.43a	3.15b	3.30b	2.10	2.07
1000+100+50 (T2)	7.50b	7.41b	9.83a	9.56a	2.80c	2.91c	2.11	2.10
1500+150+75 (T3)	5.91c	5.78c	8.90a	9.39a	2.37d	2.48d	2.03	2.07
2000+200+100 (T4)	6.34c	5.67c	9.50a	9.41a	2.71c	2.50d	2.10 n.s.	2.07 n.s.

Means followed by the same letter in a column do not differ significantly according to Duncan's New Multiple Range t-Test at P=0.05

3. Chemical composition:

From data listed in Table (5), it can be concluded that chlorophyll a, carotenoids and total soluble sugars concentrations (mg/g f.w.) were increased in the leaves of plants that received the low and medium rates of toxic metals (T1 and T2 treatments), but were diminished by the highest rates (T3 and T4 treatments). However, chlorophyll b concentration was decreased by all elemental treatments. This may be due to the indirect effects of heavy metals on photosystems related to the disturbances caused by such metals in Calvin cycle reactions and down-regulation or even feedback inhibition of electron transport by the excessive amounts of ATP and NADP (Krupa *et al.*, 1993). Besides, Droppa *et al*. (1996) suggested that Cd in greening leaves interferes with chlorophyll biosynthesis, acts mainly by inhibiting the LHC (light-harvesting complex) synthesis into stable complexes required for normal functional photosynthesis activity.

The percentages of nitrogen (N) and phosphorus (P) in the leaves of elemental-contaminated plants were fluctuated (Table, 5), but greatly decreased by the highest levels of toxic metals (T4). This was not true for potassium (K) percentage in the leaves (Table, 5), as well as lead (Pb), cadmium (Cd), and nickel (Ni) concentrations (ppm) in the leaves and roots (Table, 6), as they were progressively increased in response to the gradual increment of heavy metals concentration. So, the highest concentrations of K, Pb, Cd, and Ni were noticed in organs of plants polluted with the highest rates of metals. However, the concentration of Pb, Cd, and Ni was found higher in leaves than in roots pointing to their transmission from roots to leaves.

Table (5): Effect of heavy metals combinations on some constituents concentrations in the leaves of *Hibiscus rosa-sinensis*, L. plants in 2019 season.

Heavy metals combinations (Pb+Cd+Ni, ppm)	**Pigments (mg/g f.w.)**			**Total soluble sugars (mg/gf.w.)**	**N (%)**	**P (%)**	**K (%)**
	Chlo. A	Chlo. B	Carot.				
0.0+0.0+0.0 (Cont.)	1.808	0.373	0.697	0.750	1.805	0.530	0.692
500+50+25 (T1)	1.883	0.354	0.724	0.853	1.658	0.628	0.745
1000+100+50 (T2)	1.927	0.361	0.772	0.855	1.731	0.557	0.789
1500+150+75 (T3)	1.740	0.332	0.643	0.731	1.838	0.408	0.813
2000+200+100 (T4)	1.581	0.287	0.575	0.573	2.490	0.355	0.837

Table (6): Effect of heavy metals combinations on lead, cadmium, and nickel concentrations in the leaves and roots of *Hibiscus rosa-sinensis*, L. plants in 2019 season.

Heavy metals combinations (Pb+Cd+Ni,ppm)	**Pb (ppm)**		**Cd (ppm)**		**Ni (ppm)**	
	leaves	**Roots**	**leaves**	**Roots**	**leaves**	**Roots**
0.0+0.0+0.0 (Cont.)	26.276	8.425	1.731	0.605	5.685	1.878
500+50+25 (T1)	37.459	26.501	2.433	1.567	7.601	2.976
1000+100+50 (T2)	51.235	52.672	3.503	2.769	10.747	5.467
1500+150+75 (T3)	74.398	53.580	4.786	3.058	17.636	7.715
2000+200+100 (T4)	98.976	55.101	6.471	3.615	24.623	10.853

Absorption of metals by roots of plants grown in soil contaminated with heavy metals may be reasonable either to keep the equilibrium between their concentrations in soil solution and nutrients content in plant cells (Manousaki and Kalogerakis, 2009) or owing to the high amount of parenchyma in their tissues, as suggested byDissanayaki *et al* (2002) on *Albizia odoratissima*, *Lantana camara* and *Weddelia trilobata*. Such gains, however, are in harmony with those detected by Shahin et al. (2002) on *Salvia splendes* and *Vinca rosea* cvs. Alba and Major, Shahin *et al* (2007) on *Matthiola incana* and *Dimorphotheca ecklonis*, Wang *et al* (2012) on *chlorophytum comosum*, Forte and Mutiti (2017) on *Helianthus annuus* and *Hydrangea industrial* and Omar (2018) who implied that pigments, total soluble sugars, N and P contents in the leaves of *Sambucus nigra* and *Bauhinia purpurea* were linearly decreased with increasing concentrations of Pb, Cd, and Ni in the soil, while concentrations of these metals in leaves and roots were progressively increased as their levels in the soil was increased. Further, Safari *et al.* (2018) mentioned that *Nerium oleander* and *Conocarpus erectus* plants grown in industrialized area absorbed higher amounts of Ni, Pb, V, and Co metals than *Bouganinvillea spectabilis* and *Hibiscus rosa-sinensis* ones.

In summary, it can be advised to culture *H. rosa-sinensis* plant in elemental-contaminated areas with high concentrations due to its high resistance and survival under these conditions.

REFERENCES

Bailey, L.H. (1976) Hortus Third. Macmillan Publishing Co., Inc., 866 Third Avenue, New York, N.Y., 10022. Pp.1290.

Bessonova, V.P. (1993) Effect of environmental pollution with heavy metals on hormonal and trophic factors in buds of shrub plants. Russian Journal of Ecology, 24 (2): 91 – 95.

Bhaduri, A.M. and Fulekar, M.H. (2015) Biochemical and RAPD analysis of *Hibiscus rosa-sinensis* induced by heavy metals. Soil Sediment. Contam., 24: 411 – 422.

Blak, C.A. (1956). Methods of Soil Analysis. Part I and II. Amer. Soc. Agron. In Pupl. Madison. Wise U.S.A.

Cottenie, A.; Verloo, M.; Kiekan, L.; Velghe, G. and Comerlynck, R. (1982) Chemical Analysis of Plants and Soils. Laboratory of Analytical and Agrochemistry, State Univ., Ghent-Belgium, p: 44 – 45.

Dissanayake, U.S.; Tennakoon, K.U. and Priyantha, N. (2002) Potential of two invasive plant species, *Lantana camara*, L. and *Weddelia trilobata*, L. , for selective heavy metal uptake. Ceylon J. Sci. & Bio. Sci., 29: 1 -11.

Droppa, M.; Oravecz, A.; Boddi, B. and Horvath, G. (1996) Heavy metals inhibition of photosynthetic membrane. Proc. 1st Egypt-Hung. Hort. Conf., 1: 13 -18

Dubois, M.; Smith, F.; Illes, K.A.; Hamilton, J.K. and Rebers, P.A. (1966) Colorimetric method for determination of sugars and related substances. Ann. Chem., 28(3): 350 – 356.

Ehsan, M.; Nawaz, R.; Ahmed, S.; Khan, M.M. and Hayat, J. (2016) Phytoremediation of chromium-contaminated soil by an ornamental plant, Vinca (*Vinca rosea*, L.). J. Environ. & Agric. Sci., 7: 29-34.

Eid, Rawia, A.; Mazhar, Azza, A.; Khalifa, R.Kh. and Shaaban, S.H. (2016) Effect of cadmium concentrations on the vegetative growth, flowering and chemical constituents of *Tagetes erects*, L. plant. Inter. J. PharmaTech. Res., USA, 9(4): 18 – 24.

Erdogan, R.; Zaimoglu, Zeynep; Budak, F. and Koseoglu, C. (2011) Use of sewage sludge in growth media for ornamental plants and its effects on growth and heavy metal accumulation. J. Food, Agri. & Environ., 9(2): 632 – 635.

Forte, J. and Mutiti, S. (2017) Phytoremediation potential of *Helianthus annuus* and *Hydrangea 650ndustrial* in copper and lead-contaminated soil. Water, Air & Soil Pollution, 228: 77 – 80.

Jadhav, V.M.; Thorat, R.M.; Kadam, V.J. and Sathe, N.S. (2009) Traditional medicinal uses of *Hibiscus rosa-sinensis*. J. Pharmacy Res., 2(8): 1220 – 1222

Khan, Z.A.; Naqvi, S.A.; Mukhtar, A.; Hussain, Z.; Anjum, S; Mansha, A.; Ahmed, M.; Zahoor, A.F.; Bukhari, I.H.; Janjua, S.A.; Mahmood, N. and Yar, M. (2014) Antioxidants and antibacterial activites of *Hibiscus rosa-sinensis*flower extracts. Pakistan J. Pharm. Sci., 27: 469 – 474.

Krupa, Z.; Siedlecka, A.; Maksymiec, W. and Baszynski, T. (1993)*In vivo* response of photosynthetic apparatus of *Phaseolus vulgaris*, L. to nickel toxicity. J. Plant Physiol., 142(6): 664 – 668.

Manousaki, E. and Kalogerakis, L. (2009) Phytoextraction of Pb and Cd by the 650ndustrially650 saltbush (*Atriplex halimus*, L.): metal uptake in relation to salinity. Environ. Sci. & Pollu. Res., 16(7): 844 – 854.

Mead, R.; Curnow, R. N. and Harted, A. M. (1993)Statistical Methods in Agriculture and Experimental Biology. 2nd Ed., Chapman & Hall Ltd., London, 335 pp.

Noman, A.; Aqeel, M.; Javed, M.T.; Zafar, S.; Ali, Q.; Islam, W.; Irshad. M.K.; Buriro, M.; Kanwal, H.; Khalid, N. and Khan, S. (2017) Histological changes in *Hibiscus rosa-sinensis* Endorse acclimation and phytoremediation of 651ndustrially polluted sites. The J. Anim. & Plant Sci., 27(5): 1637 – 1648.

Omar, Sohair H.M. (2018) Studies on tolerance of some ornamental plants to soil pollution with some combinations of heavy metals. M.Sc. Thesis, Fac. Agric., Kafrelsheikh Univ., 127 pp.

Page, A.L.; Miller, R.H. and Keeny, D.R. (1982) Methods of Soil Analysis: part II., Chemical and Microbiological Properties "2" ed. Agron. Madison, Wisconsin, U.S.A

Rai, P.K.; Panda, L.S.; Chutia, B.M. and Sigh, M.M. (2013) Comparative assessment of air pollution tolerance index (APTI) in the industrial (Rourkela) and non-industrial (Aizawl) area of India: An ecomanagement approach. African J. Environ. Sci. & Tech., 7(10): 944 – 948.

Ramana, S.; Biswas, A.K.; Singh, A.B.; Ahirwar, N.K. and Subba Rao, A. (2015) Tolerance of ornamental succulent plant Crown of Thorns (*Euphorbia milli*) to chromium and its remediation. Inter. J. Phytoremediation, 17(4): 363 – 368.

Safari, M.; Ramavandi, B.; Sanati, A.M.; Sorial, G.A.; Hashemi, S. and Tahmasebi, S. (2018) Potential of trees leaf/bark to control atmospheric metals in a gas and petrochemical zone. J. Environ. Management, 222: 12 – 20.

SAS Institute (2009) SAS/STAT User's Guide: Statistics, Vers. 6.04, 4th Ed, SAS Institute. Inc., Cary, N. C., USA.

Shahin, S.M.; El-Shakhs, M.H. and Abdel-Salam, M.H. (2002) Impact of lead, cadimium and mercury combinations on growth, flowering and chemical composition of *Salvia splendes*, L. and *Vinca rosea*, L. 2nd Inter. Conf. Hort. Sci., 10 -12 sept., Kafr El-Sheikh, Tanta Univ., 911 – 920.

Shahin, S.M.; Mahmoud, A.M.A. and El-Feky, A.H. (2007) How far stock and cape marigold plants can tolerate toxicity of some heavy metals combitions? J. Biol. Chem. & Environ. Sci., 2(2): 415-433.

Shrivastava, R. and Prakash, J. (2017) Effect of vehicular pollution on micro-morphological structure of *Hibiscus rosa-sinensis*. Inter. J. Engin. Tech. Sci. & Res. (IJETSR), 4(12): 521-527.

Steel, R. G. and Torries, J. H. (1980) Principles and Procedures of Statistics. McGraw Hill Book Co., Inc., New York, P: 377 – 400.

Sumanta,N.; Haque, C.I.; Nishika, J. and Suprakash, R. (2014) Spectrophotometric Analysis of chlorophyllous and carotenoids from commonly grown *Fern sp.* by using various extracting solvents. Research J. Chem. Sci., 4(9): 63 – 69.

Tauqeer, H.M. Ali, S.; Rizwan, M.; Ali, Q.; Saeed, R.; Iftikhar, U.; Ahmed, R.; Farid, M. and Abbasi, G.H. (2016) Phytoremediation of heavy metals by *Alternanthera bettzickianan*: growth and physiological response. Ecotoxicol. And Environ. Saf., 126: 138 – 146.

Wang, X. and Zhou, Q. (2005) Ecotoxicological effects of cadmium on three ornamental plants. Chemosphere, 60(1): 16 -21.

Wang, Y.; Yan, A. and Dai, J. (2012) Accumulation and tolerance characteristics of cadmium in *Chlorophytum comosum*: a popular ornamental plant and potential Cd hyperaccumulator. Environmental Monitoring and Assessment., 184(2): 929 -937.

Wilkins, D.A. (1957) Atechnique for the measurement of lead tolerance in plants. Nature, 180: 73 – 78

Yasmin, S. (2010) Studies on bioactive natural products of selected species of family Malvaceae. Ph.D. Thesis, Government College Univ., Lahore, Pakistan.

ZhiGuo, T. and Wang, F. (2013) Growth and physiological response of Tagetes cultivars to cadmium stress. Acta Botanica Boreali-Occidentalia Sinica, 33(10): 2057 – 2064.

إلى أي مدى تستطيع شتلات الورد الصيني (*Hibiscus rosa-sinensis*, L.) تحمل سمية بعض العناصر الثقيلة في توليفات

سيد محمد شاهين , أحمد محمد على محمود, ريم محمد سعيد
قسم بحوث الحدائق النباتية ,معهد بحوث البساتين,مركز البحوث الزراعية , الجيزة , مصر

ما زال البحث عن نباتات زينة تتحمل التلوث مستمراً كبديل قليل التكلفة و فعال لمواجهة هذا التحدي. لذلك، أجريت هذه الدراسة تحت الشمس الساطعة بحديقة الأورمان النباتية، الجيزة، مصر- خلال موسمي 2018 ، 2019 لمعرفة مدى تحمل شتلات عمر ستة أشهر من الهبسكس الصيني (*Hibiscus rosa-sinensis*, L.) النامية في أكياس بلاستيك سوداء قطرها 20 سم و مملوءة بحوالي 4 كجم من مخلوط الرمل+ الطين (بنسبة 1:1 حجماً) لسمية عناصر الرصاص(Pb) ، الكادميوم (Cd)، النيكل (Ni)عند إضافتها للتربة كأملاح خلات في توليفات بالتركيزات التالية: صفر (جزء في المليون) لكل عنصر- كمقارنة، 500 جزء في المليون Pb+ 50 جزء في المليون Cd+ 25 جزء في المليون Niلتوليفة المعاملة الأولى(T1) ، بجانب ضعف، ثلاثة و أربعة أضعاف هذه التركيزات لتوليفات المعاملة الثانية (T2)، الثالثة (T3)و الرابعة (T4)،على التوالي.

أوضحت النتائج المتحصل عليها عدم حدوث موت لأي من نباتات الهبسكس المعاملة بالملوثات المعدنية ، معطية نسبة بقاء (حياة) 100% مثل المقارنة، على الرغم من أن متوسطات قياسات النمو الخضري و الجذري لهذه النباتات قد أنخفضت تدريجيا بزيادة تركيزات العناصر الثقيلة في معظم الحالات بكلا الموسمين. و عليه، فإن أقصر- النباتات، أقلها حجماً و أخفها وزناً (طازجاً و جافاً) أحرزتها توليفة المعاملة الرابعة (T4) ، تلتها توليفة المعاملة الثالثة (T3). و لقد أنخفضت النسبة المئوية لدليل تحمل التلوث (PRI%) ، كمؤشر حقيقي لقدرة النبات على مقاومة إجهاد التلوث بالعناصر الثقيلة، إنخفاضا معنويا و بشكل تدريجي كلما زادت تركيزات العناصر الثقيلة لتصبح أكثر من 80% بكلا الموسمين،حتى للنباتات التي تعرضت للتركيزات العالية من العناصر السامة بالمعاملة الرابعة (T4)، مشيرة إلى القدرة العالية لهذا النبات على مواجهة أضرار تلك العناصر. و لقد أنخفضت متوسطات قطر الزهرة و وزنها الطازج بشكل متزايد كلما زادت تركيزات العناصر الثقيلة، بينما كان العكس صحيحاً فيما يتعلق بطول عنق الزهرة، و الذي زادت متوسطاته على متوسط المقارنة بتأثير جميع المعاملات. أما الوزن الجاف للزهرة فلم يتأثر بأي من هذه المعاملات. أظهرت النتائج أيضاً زيادة محتوى الأوراق من كلورفيل أ، الكاروتينويدات و السكريات الكلية الذائبة بالنباتات المعاملة بالتركيزات المنخفضة و المتوسطة (T2 ,T1)، لكنها أنخفضت بأوراق النباتات المعاملة بالتركيزات فوق المتوسطة و المرتفعة (T3, T4). أما محتوى الأوراق من كلوروفيل ب فقد أنخفض متأثرا بجميع المعاملات. أما النسب المئوية لعنصري النتروجين و الفوسفور بأوراق النباتات المعاملة بالملوثات المعدنية فقد كانت متقلبة، لكنها أنخفضت بشكل واضح بالمعاملة الرابعة (T4). و لم يكن ذلك حقيقيا لمحتوى الأوراق من البوتاسيوم، و كذلك محتوى الأوراق و الجذور من عناصر الرصاص ، الكادميوم، النيكل و التي زادت تدريجياً بالزيادة التدريجية لتركيزات العناصر الثقيلة. و لقد كان محتوى الأوراق من عناصر الرصاص، الكادميوم، النيكل أعلى منه في الأوراق عنالجذور مما يشير إلى أنتقال هذه العناصر من الجذور إلى الأوراق.

طبقا لهذه النتائج، يمكن التوصية بزراعة نبات الورد الصيني (*Hibiscus rosa-sinensis*, L.) في المناطق الملوثة بتركيزات مرتفعة من عناصر الرصاص، و الكادميوم و النيكل بسبب مقاومتها المرتفعة لسمية هذه العناصر و بقاءها حية تحت هذه الظروف.

الكلمات المفتاحية: الورد الصيني، تلوث التربة ، المعادن الثقيلة، مؤشر مقاومة التلوث