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

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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 (Taufeer 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, antitussive, 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 Apyentia cordifolia, Wang et al. (2012) on chlorophytum comosum, Ramana et al. (2015) on Euphorbia millii, Ehsan et al. (2016) on Vinca rosea, Forte and Mutiti (2017) on Helianthus annuus 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 | Mg²⁺ | Ca²⁺ | Na⁺ | K⁺ | HCO₃⁻ | Cl⁻ | SO₄²⁻ |
| 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 (CH₃CO₂)₂], cadmium [Cd (CH₃CO₂)₂] and nickel [Ni (CH₃CO₂)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:

- 0.00 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 (cm²), 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):

$$\text{PRI(%) = Mean root length of the polluted plant/ mean root length of control one} \times 100$$

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 (cm²), 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 Kalezorakis (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. Coopery 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            |
| 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            | 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 (cm²) | Petiole length (cm) | Root length (cm) | No. roots/plant | Pollution resistance index (PRI %) |
|----------------------------------------|-----------------|---------------------|------------------|-----------------|----------------------------------|
|                                        | 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 Multiple 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.)                       | 10.31 | 10.09 | 6.25  | 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  | 2.07 |

Means followed by the same letter in a column do not differ significantly according to Duncan’s New Multiple Range 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 functionalphotosynthesis 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) | Chlo. A (%) | Chlo. B (%) | Carot. (%) | Total soluble sugars (mg/gf.w.) | N (%) | P (%) | K (%) |
|------------------------------------------|------------|------------|------------|-------------------------------|-------|-------|-------|
| 0.0+0.0+0.0 (Cont.)                       | 1.805      | 0.373      | 0.697      | 0.750                         | 1.805 | 0.530 | 0.692 |
| 500+50+25 (T1)                            | 1.885      | 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 by Dissanyake et al. (2002) on Albizia odoratissima, Lantana camara and Weddellia trilobata. Such gains, however, are in harmony with those detected by Shahin et al. (2002) on Salvia splendens and Vinca rosea cvs. Alba and Major, Shahin et al (2007) on Matthiola incana and Dimorphotheca ecklonis, Wang et al (2012) on chlorophytm 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.

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أجريت هذه الدراسة تحت الشمسم النباتية مدينة الأورام بالفسفور (Hibiscus rosa-sinensis, L.)، في مركز بحوث البساتين، معهد بحوث البساتين، القاهرة، مصر، خلال موسم 2018. تم استخدام ثلثين نبات لكل درجة من فصوص الأوراق الخضراء (Pb، Cu، Ni، Cd) معبدة على درجة حرارة 100 درجة مئوية، وتم اضافة كل منها إلى وعاء ماء، مع وضع النباتات في الوعاء الماء أيضًا، لتعبر عن درجة حرارة 100 درجة مئوية. تم اضافة كل منها إلى وعاء ماء، مع وضع النباتات في الوعاء الماء أيضًا، لتعبر عن درجة حرارة 100 درجة مئوية.

أجريت هذه الدراسة تحت الشمسم النباتية مدينة الأورام بالفسفور (Hibiscus rosa-sinensis, L.)، في مركز بحوث البساتين، معهد بحوث البساتين، القاهرة، مصر، خلال موسم 2018. تم استخدام ثلثين نبات لكل درجة من فصوص الأوراق الخضراء (Pb، Cu، Ni، Cd) معبدة على درجة حرارة 100 درجة مئوية، وتم اضافة كل منها إلى وعاء ماء، مع وضع النباتات في الوعاء الماء أيضًا، لتعبر عن درجة حرارة 100 درجة مئوية. تم اضافة كل منها إلى وعاء ماء، مع وضع النباتات في الوعاء الماء أيضًا، لتعبر عن درجة حرارة 100 درجة مئوية.

أجريت هذه الدراسة تحت الشمسم النباتية مدينة الأورام بالفسفور (Hibiscus rosa-sinensis, L.)، في مركز بحوث البساتين، معهد بحوث البساتين، القاهرة، مصر، خلال موسم 2018. تم استخدام ثلثين نبات لكل درجة من فصوص الأوراق الخضراء (Pb، Cu، Ni، Cd) معبدة على درجة حرارة 100 درجة مئوية، وتم اضافة كل منها إلى وعاء ماء، مع وضع النباتات في الوعاء الماء أيضًا، لتعبر عن درجة حرارة 100 درجة مئوية. تم اضافة كل منها إلى وعاء ماء، مع وضع النباتات في الوعاء الماء أيضًا، لتعبر عن درجة حرارة 100 درجة مئوية.

أجريت هذه الدراسة تحت الشمسم النباتية مدينة الأورام بالفسفور (Hibiscus rosa-sinensis, L.)، في مركز بحوث البساتين، معهد بحوث البساتين، القاهرة، مصر، خلال موسم 2018. تم استخدام ثلثين نبات لكل درجة من فصوص الأوراق الخضراء (Pb، Cu، Ni، Cd) معبدة على درجة حرارة 100 درجة مئوية، وتم اضافة كل منها إلى وعاء ماء، مع وضع النباتات في الوعاء الماء أيضًا، لتعبر عن درجة حرارة 100 درجة مئوية. تم اضافة كل منها إلى وعاء ماء، مع وضع النباتات في الوعاء الماء أيضًا، لتعبر عن درجة حرارة 100 درجة مئوية.