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الاستخلاص النباتي وتحمل التربة الملوثة بالرصاص و الكادميوم بواسطة شتلات السبحبح تحت الظروف الحقلية

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المستخلص :

إن الهدف من هذه الدراسة هو تقييم التحمل والكفاءة شتلات السبحبح (Melia azedarach L.) في استخلاص الكادميوم (Cd) والرصاص (Pb) من التربة الملوثة ، مع معرفة سلوكها في امتصاص وتراكم هذه المعادن في أجزاء المختلفة للنبات، بالاعتماد على بعض مقاييس تقنية المعالج النباتي (Phytoremediation) لتقييم مدى ملائمة هذه الشجرة في تقنية المعالجة النباتية. أجريت التجربة من بداية شهر اذار حتى نهاية شهر حزيران لعام ٢٠٢٢ باستخدام شتلات M. azedarach بعمر عام واحد والتي تم تربيتها في الاصص البلاستيكية تحتوي على ١٠ كغم خليط تربة جافة يتكون من (١ تربة طينية رملية: ١ تربة حقلية) والتي عوملت بتراكيز (0 Cd، 25، 50، 75، 100) ملغم.كغم-١ تربة جافة على هيئة CdCl2.2,5 H2O، و تركيزات (0 Pb، 200، 400، 600، 800) ملغم.كغم-١ تربة جافة على هيئة PbCl2، مع العلم أن تربة الكنترول تحتوي على ٠.١٤٩ و ٤.٣٩٥ ملغم.كغم-١ تربة جافة منCd وPb ملغم.كغم-١ على التوالي، صممت التجربة حسب تصميم القطاعات العشوائية الكاملة. أظهرت النتائج أن التربة الملوثة بمستويات مختلفة من Cd وPb كان لها تأثير بارز على معظم صفات المدروسة لشتلات M. azedarach وكذلك تراكم هذه المعادن في أجزاء المختلفة للنبات. تزداد هذه التأثيرات مع زيادة تركيز هذه المعادن الثقيلة في التربة. تأثير Pb على الكتلة الحيوية لمجموع الخضري و محتوى الكلي للكلوروفيل كان أكثر مقارنةً مع Cd ، و أيضاً تأثرت الكتلة الحيوية للجذر بالكادميوم أكثر من الرصاص. كان المحتوى المتراكم لهذين المعدنين في نظام الجذري أكثر من نظام الخضري دون

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ترك أي أعراض سامة، مما يشير إلى أن هذه الشجرة تعتبر معالج نباتي مقاوم وملائم للتربة الملوثة بـ Cd و Pb.

كلمات المفتاحية: المعالجة النباتية ، الكادميوم، الرصاص.

Phytoextraction and Tolerance of Pb and Cd-Polluted Soil by Melia azedarach L. Seedlings under Field Conditions

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ABSTRACT :

The aim of this study is to evaluate the tolerance and efficiency of Chinaberry (Melia azedarach L.) seedlings in extracting Cadmium (Cd) and Lead (Pb) contaminated soil, knowing its behavior in absorbing and accumulating these metals in different plant parts, based on some phytoremediation parameters to evaluate the suitability of this tree in phytoremediation technique. The experiment was conducted from early March to the end of June 2022 using one-year-old M. azedarach seedlings raised in plastic pots containing 10 kg dry soil mixture consisting of (1 sandy soil: 1 field soil) which was treated with concentrations of Cd as CdCl2.2,5 H2O (0, 25, 50, 75, 100) mg.kg-1, and concentrations of Pb as PbCl2 (0, 200, 400, 600, 800) mg.kg-1, with remembering that the soil of control contains 0.149 and 4.395 of Cd and Pb mg.kg-1 respectively. the experiment was designed as a factorial design by applying a randomized complete block design (RCBD). The results showed that the soil contaminated with different levels of Cd and Pb had a significant impact on most study traits of M. azedarach seedlings as well as the content of these metals in different plant parts. These effects increase with increasing concentration of these heavy metals in the soil. Shoot biomass and content of total chlorophyll were negatively affected by Pb more than by Cd, likewise, root biomass was affected by Cd more than Pb. The accumulated content of these two metals in the root system was more than the shoot system without leaving any toxic

symptoms, indicating that this tree is considered tolerant and a suitable phytoremediator to the soil polluted with Cd and Pb.

Key words: Phytoremediation, Cd, Pb.

* part of M.Sc. Thesis of 1st author

Introduction :

Environmental pollution is referring to the presence of any contaminating material in the surroundings in amounts that endanger public health or harm ecosystem whether in their own or in combination with other pollutants, either directly or indirectly. The soil is deemed to be contaminated, when a material or materials that threaten human, animal, or plant health or change the natural equilibrium of both ground and surface water are present in soil in sufficient amounts. Environmental pollution, especially heavy metals are among the most threatening pollutant to the ecosystem of living things. It is caused by leftover human activity and technological waste, including mineral extraction, industrial facilities, electricity generation plants, hospitals, sewage waste, human consumption waste, public transit, agricultural pesticides, and the mineral origin of the earth's crust (Zhang, et al., 2019; Al-Khazan and Al-Zlabani, 2019 and Vardhan et al., 2019). Heavy metal pollution is a major problem due to its prevalence as a contamination source, limited solubility, and categorization as carcinogenic and mutagenic (Diels et al., 2002). Pb is widespread in nature than the other highly dangerous heavy metals. When Pb is persistent in plant tissues, it inhibits photosynthesis and interferes with the function of stomata in leaves, which limits vegetative development. Due to its high concentrations, which cause cellular stress and ultimately plant death, it inhibits enzymatic activity in plant tissues (El-Mahrouk et al., 2019; Andrade Junior et al., 2019; Zhou et al., 2018; Hussain et al., 2018). Cd is among the most harmful heavy metals to the environment. It is recognized for its high toxicity even at low concentrations and for moving quickly into cellular tissues, where it settles and causes morphological, physiological, and biochemical changes while working to slow down plant growth, photosynthesis, and cellular processes. Plant mortality and cell damage result from its critical concentrations (Ismael et al., 2019; Mizushima et al., 2019). The low-cost, ecological friend, and suitable solution approach to remediate polluted soil, sediments, and water is phytoremediation by using green plants (Rafati et al., 2011). New researches have supported the use of forest trees in the decontamination of heavy metal-polluted ecosystems due to they can provide a range of ecological benefits and are crucial to the plant's ability to maintain life and do not contribute to the food chain, by choosing those species that have high biomass production, ability to grow in poor soil, fast growing and have dep root system, potentiality to resist heavy metals, and a second use that is financially sustainable. Additionally, they can offer the chance for multiple cycles of purification without having to harvest entire plants or regrow ones annually (Gebretsadik et al., 2020; Mleczek et al., 2010; Pilon, 2005; Punshon et al., 1996). The purpose of this study was to assess the ability of M. azedarach L. seedlings in extracting Cd and Pb from soil under field condition with and their effects on growth parameters.

MATERIALS AND METHODS

This study was carried out in Malta Forest Nursery-Duhok, which belongs to the General Directorate of Forests and Rangeland. The range lands are located at an altitude of 506 (masl), latitude (36º 52-, 01 N), and longitude (42º56-, 18 E). The climatic data of the study site during the study period (2021-2022) (Meteorological station- Duhok in Table (1). At the beginning of October 2021, the soil samples were collected from the field soil of Malta Forest Nursery at a depth of (0-20 cm), then mixed with the same soil media used to raise seedlings in polyethylene bags (sandy loam soil) with the ratio of (1 sandy loam soil: 1 field soil) sub sample was taken and sieved through a 2.0 mm sieve for analyzing some of physical and chemical characteristics and heavy metals content of soil media used in the experiment according to the method indicated by (Page, et al., 1982) and A.O.A.C, (1995), in the Laboratory of soil department of College of Agricultural Engineering Sciences (table 2), seven-month-old uniform seedlings of Melia azedarach were brought from Zakho Forest Nursery to the field of Malta Forest Nursery, then they were cultivated in plastic pots

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filled with 10 kg of soil. The seedlings were distributed into four blocks and irrigated well regularly with tap water till the time for the application of treatments according to the approved design in order to become stable and adapted to the new field conditions. at the beginning of March 2022 one–year old seedlings were treated with concentrations of Cd in the form of Cadmium Chloride 2,5-hydrate, extra pure CdCl2.2,5 H2O (0, 25, 50, 75, 100) mg kg-1 dry soil and with concentrations of Pb in the form of Lead chloride Pbcl2 (0, 200, 400, 600, 800) mg kg-1 dry soil, in a factorial experiment (5*5) and designed by applying randomized complete block design (RCBD). Data were statistically analyzed SAS statistical program, and the differences between various treatment means were tested with the Duncan Multiple Range tests at a 5% level. At the end of June 30, 2022, the plants were harvested and washed to remove any soil remains and placed in plastic bags. Then, they were transferred to the Laboratory Center of Research of the Agriculture Engineering Science College, Duhok University. Leaves were taken from each experimental unit from field and immediately taken to laboratory to extract total chlorophyll content according to the method of Knudsen which illustrated in Wintermans and DemMots (1965) by using following equations: Chl. a = (13.7) (A 665nm) - (5.76) (A 649nm) Chl. b = (25.8) (A 649nm) - (7.6) (A 665nm), Total Chl. = (Chl. a) + (Chl. b). The seedlings were separated into roots, stems, and leaves by electrical plant pruning scissors, later plant parts were oven dried at a temperature of 65 C° for 72 hours until to constant weight (AOA.C, 1970) After that, the dry weights of roots, stems and leaves were recorded immediately by using a digital balance. Lastly, plant samples were ground to a fine powder to be ready for digestion to measure Cd and Pb content in plant parts according to the procedure (Patel et al., 1996). Then estimating the mechanisms and parameters of plant efficiency in extracting Cd and Pb from the soil which includes: the Translocation Factor (TF) of the tested plant as reported by (Rasheed et al., 2020), as in the following equation: TF = HMs / HMr Where, HMs= the concentration of heavy metals in the shoot system, HMr= the concentration of heavy metals in the root system. Bioaccumulation coefficient (BAF) was calculated as reported by (Chandra

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and Hoduck, 2018) and as in the following equation: BAC = HM Shoot / HM soil Where, HM shoot = concentration of heavy metals in Stem and Leaves, HM soil= Concentration of heavy metals in Soil. Bioconcentration Factor (BCF) was calculated as reported by (Chandra and Hoduck, 2018) in the following equation: BCF = HM Root / HM soil Where HM Root = the concentration of heavy metals in the roots. HM soil = the concentration of heavy metals in the soil. And Translocation Index (TI) was calculated according to the method reported by (Xu, et al., 2019) based on dry weight of entire plant as in the following equation: TI =DWHM / DW control Where, DWHM = total dry weight of plant treated with heavy metals. DW control = total dry weight of control plant.

Table 1/ Some of physical and chemical characteristics and heavy metals content of soil used in the experiment

Parameters	Value
Sand	35.525%
Silt	48%
Clay	16.475%
Texture	Laom
EC	0.423 $dS.m^{-1}$
Ph	8.23
Total $CaCo_2$	15.23%
Organic matter	0.85%
Pb	4.395 $mg.kg^{-1}$
Cd	0.149 $mg.kg^{-1}$
Cation Exchange Capacity (CEC)	9.94 Meq/100g

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Table 2/The climatic data of the study site during the study period (2021-2022)

Year	2021			2022					
Mon.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.
Rain	2.4	2	44.5	74.5	8.6	44.1	17.8	54.7	0.7
RH	39.7	53	66	76.6	61.9	59.5	38	42.7	27.2
Temp.(Max.)	28.7	22.5	15.5	10.5	16.5	15.1	26.9	29.3	38.6
Temp.(min.)	15.5	10.5	6.1	2.4	5.9	5.7	14.4	16.9	24.7

RESULTS AND DISCUSSION

1.Content of total chlorophyll (mgg-1Fw) in the leaves of Melia azedarach seedlings responded to the soil polluted with concentrations of Cd and Pb (mg kg-1 dry soil.)

The results represented in (Figure 1) showed that each of Cd and Pb significantly inhibited the content of total chlorophyll in the seedlings leaves, and it was noticed that the inhibitory effect of these two metals increased with an increase in their concentrations in the soil .The control treatment is significantly superior to all other concentrations of Cd and Pb in the soil in terms of their effects on content of total chlorophyll in seedlings leaves, thus recording the highest values of this trait amounted to (5.430) mg g-1fw, compared to the lowest values which amounted to (4.083 mg g-1fw by 24.8%) at the Cd concentration of (100) mg kg-1, and (3.383 mg g-1fw by 37.7%) at the Pb concentration of (800) mg kg-1 dry soil. Our findings are consistent with the results of many researchers among them, the findings of Khamis, et al., (2014) on M. azedarach seedlings, which were treated with various concentrations of Cd and Pb, they found the highest content of total chlorophyll in the leaves of seedlings was at the control treatment and decreased with increased concentrations of these two metals in the soil. Findings of Pant et al., (2011) on Shorea robusta seedlings , which were treated with three concentrations of Cd and Pd (1, 5 and 10) mg liter-1, the results showed a decrease in the content of chlorophyll, as the chlorophyll was significantly reduced 63.8% by Cd concentration (10 mg l-1) and 68%

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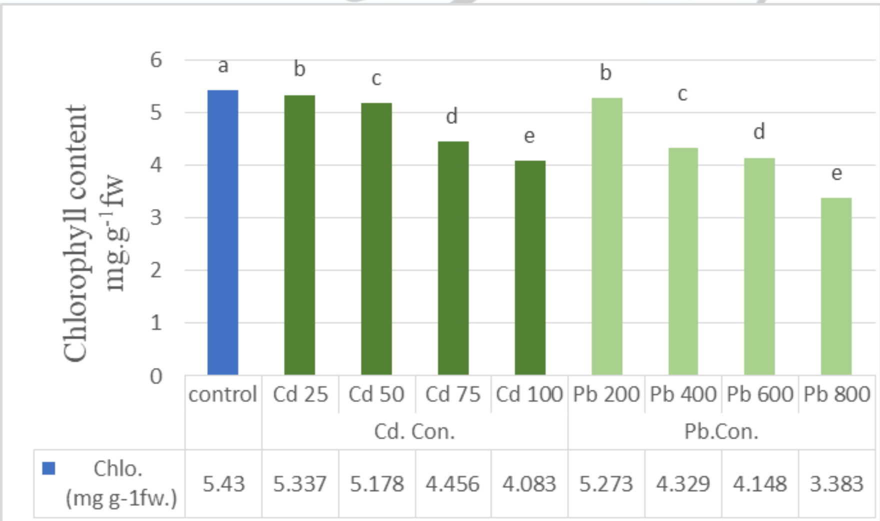
by Pb 10 mg l -1 compared to control. Results of Huang et al., (2020) in their study on Melia azedarach and Lingustrum lucidum seedlings. Photosynthetic pigments content of M. azedarach and L. lucidum were shown to decrease when soil of Pb-Zn mine tailing amounts increased as compared to the control, in M. azedarach declined by 37% and in L. lucidum decreased by 46%. The inhibition of total chlorophyll in the leaves with increased concentrations of Cd and Pb in the soil, is due to abiotic stress, including heavy metal stress, which produces large amounts of reactive oxygen species in the plant cell and causes plant tissue toxicity (Malar et al., 2016). Cd and Pb have the potential to substitute magnesium, the central component of chlorophyll, which influences the mechanism of photosynthesis by decreasing chlorophyll's ability to absorb sunlight (Kupper et al., 1996) .

Figure 1/shows Content of total chlorophyll mg g-1fw in the leave of M. azedarach Seedlings responded to the soil polluted with concentrations of Cd and Pb (mg kg-1 dry soil).

* means followed with same letters for each factor are not significantly different according to Duncan Multiple range test at probability level (0.05)



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2.Response of biomass of M.azedarach L. seedlings to the soil polluted with concentrations of Cd and Pb

The results in (Figures 2a, 2b, and 2c) showed that Cd and Pb significantly reduced the biomass (root, stem, and leaf) of seedlings. It was noticed that the effect of these two metals on the biomass of seedlings increased with increasing their concentrations in the soil. The untreated seedlings at control treatment have significantly surpassed all other concentrations of Cd and Pb in the soil in terms of their effects on the dry weight (root, stem, and leaf) of seedlings, so that gave the highest values of dry weights of these three characteristics of seedlings obtained (53.560, 73.905, and 22.528) gm respectively, were recorded with seedlings at the control treatment, compared to the lowest values of these traits reached (31.713, 56.050, and 15.884) and (38.818, 52.818, and 15.414) gm respectively, with seedlings treated with concentrations of (Cd-100 and Pd-800) mg.kg-1 dry soil respectively. It was observed that Pb was more effective than Cd in its effect on the dry weights of stem and leaves while Cd was more effective on the dry weight of roots than Pb, due to the difference between the two metals in their concentrations in both the vegetative and root systems. The findings of the biomass of seedlings are in agreement with the results obtained by a number of researchers, Bajwa (2014) on seedlings of Melia azedarach; Dalbergia sissoo; Leucaena leucocephala; Eucalyptus tereticornis Which were treated with different concentrations of Cd and Pb, and the results showed that unpolluted seedlings at control treatments of all these trees gave the highest value of dry mass compared to seedlings polluted with different concentrations of Cd and Pb. The finding of the study is in agreement with the results obtained by (Khamis, et al., 2014) on Melia azedarach and Populus alba seedlings treated with different concentrations of Cd and Pb, the biomass of the two species declined with increasing levels of both metals. The reason for the reduction in dry weight of seedlings roots, which were exposed to Cd and Pb concentrations, may be due to cellular stress, which resulted in root growth inhibition, was caused by an action that hindered root cell division and a shortage of nutrition intake, which reduced root biomass (Sharma and Dubey, 2005). Heavy metals induce oxidative

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stress in plants by creating reactive oxygen species, resulting in physiological problems and plant mortality (Ali, et al., 2015). The explanation for the decline in the biomass production of seedling stems polluted with high concentrations of Cd and Pb may be related to cellular stress, which has contributed to the elimination of growth in the tissue of plants and obstruction of the activity of micro-pipes that hinder cell expansion and inhibition by heavy metals for the action of the proton pump, which is contributing to the gradual accumulation of protein within the cell membrane and thus diminution of the growth of plants (Eun et al., 2000 and de Souza et al., 2012). The reduction in biomass produced by plant leaves subjected to toxic metals may be caused by inadequate water and nutrition uptake and transport from the root to aerial system and inside the plant's cells (Svetkova and Fargašova, 2007)

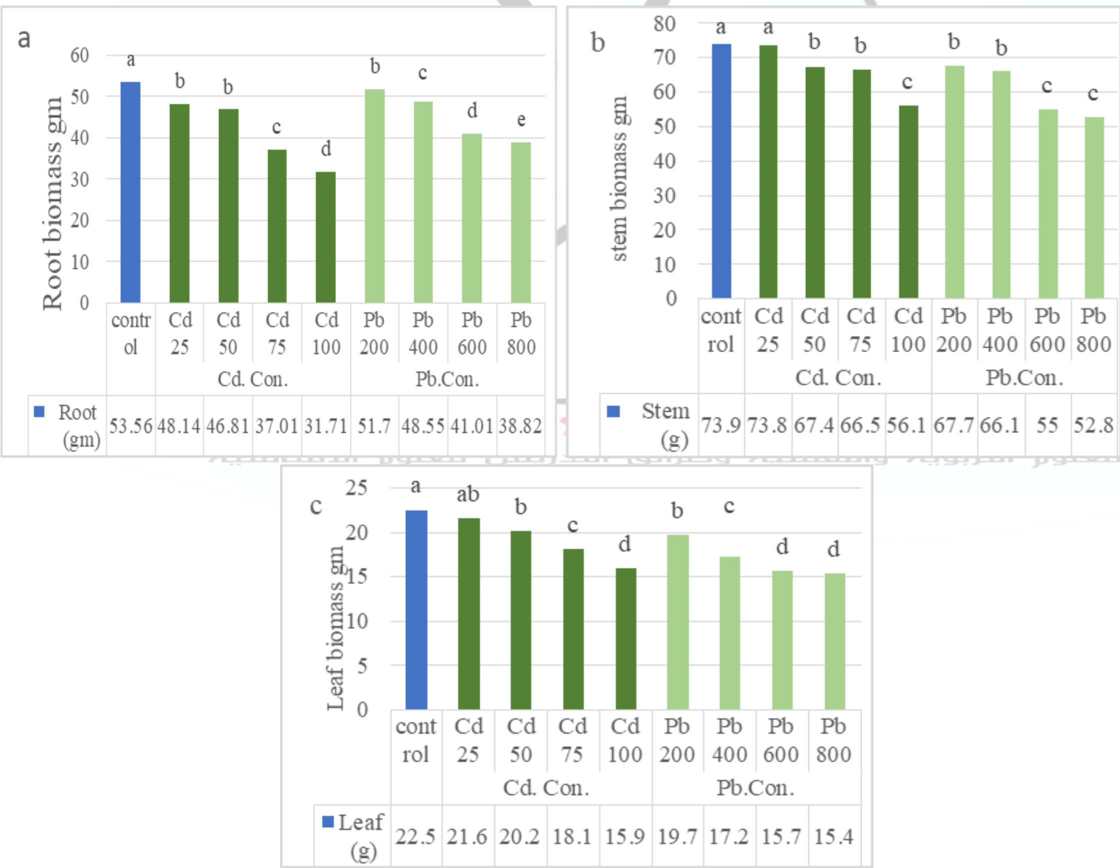

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Figure 2/Response of biomass of M.azedarach L. seedlings to the soil polluted with Cd & Pb. a/ root biomass b/ stem biomass c/ leaf biomass.
*means followed with same letters for each factor are not significantly different according to Duncan Multiple range test at probability level (0.05.(

3.Content of Cd and Pb (mg.kg -1) in parts of M.azedarach L. seedlings responded to the soil polluted with Concentrations of Cd and pd.

It is clear from the findings in (figure 3a, 3b, 3c) that there is a significant effect of both Cd and Pb concentrations in the soil on their accumulation in (root, stem and leaves) of seedlings. It is also clear that the accumulated concentrations of these two metals have increased significantly in different parts of seedlings with increasing concentrations of these two metals in the soil, recording the highest content of Cd in (root, stem and leaves) of seedlings achieved (73.152, 17.311 and 9.620) mg.kg -1 dry soil with seedlings polluted with concentrations of (Cd-100) mg.kg-1 dry soil respectively, compared to the lowest content reached (0.214; 0.038 and 0.026) mg.kg-1 dry soil respectively with untreated seedlings at the control treatment, were as, the highest content of Pb in (root, stem and leaves) of seedlings achieved (65.568, 23.812 and 21.423) mg kg-1 dry soil with seedlings polluted with concentrations of (Pd-800) mg.kg-1 dry soil respectively, compared to the lowest content reached (2.179, 0.142 and 1.085) mg.kg –1 dry soil respectively, with untreated seedlings of these two metals at the control treatment. The findings of this study are relatively consistent with the results obtained by Nofal et al., (2017) on Bauhinia purpurea L. seedlings; El - Mahrouk et al., (2019) on Salix mucronate seedling, and Khamis et al., (2014) on Melia azedarach seedlings, Amedi et al., (2022) on Platanus orientalis, Eucalyptus camaldulensis, and Populus nigra, where they found that the highest concentration of Cd and Pb were observed in the roots of seedlings polluted with various concentrations of Cd and Pb ,which were significantly superior to the lowest concentrations of these two metals were recorded in an untreated seedlings at the control, and the concentrations of metals increased with increased their concentrations in the soil. It can be seen from these results, that the largest amount of content of both Cd and Pb was mainly by root system and then by stem compared

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with little amount in leaves. the increase in Cd and Pb concentration in the roots of seedlings is caused by the plant's ability to withstand severe heavy metal stress by developing structures that encapsulate toxic metals in the vacuoles of root cells, which has been recognized as a detoxifying technique, since its endodermis is the significant heavy metal-containing regions (Wójcik et al., 2005; Shanker et al., 2005 and Lux, et al., 2004.(

The presence of Cd and Pb in the stems and leaves of seedlings may be due to excessive amount of this metal in the soil, demonstrating that as the period during which a plant is exposed to heavy metals rises, the functioning of the system of antioxidants as well as other defensive mechanisms in the plant decreases, promoting the migration of heavy metals to the vegetative system and their accumulation in cell walls, which is regarded to be toxic (Heidari, & Sarani, 2011 and Wójcik et al., 2005).

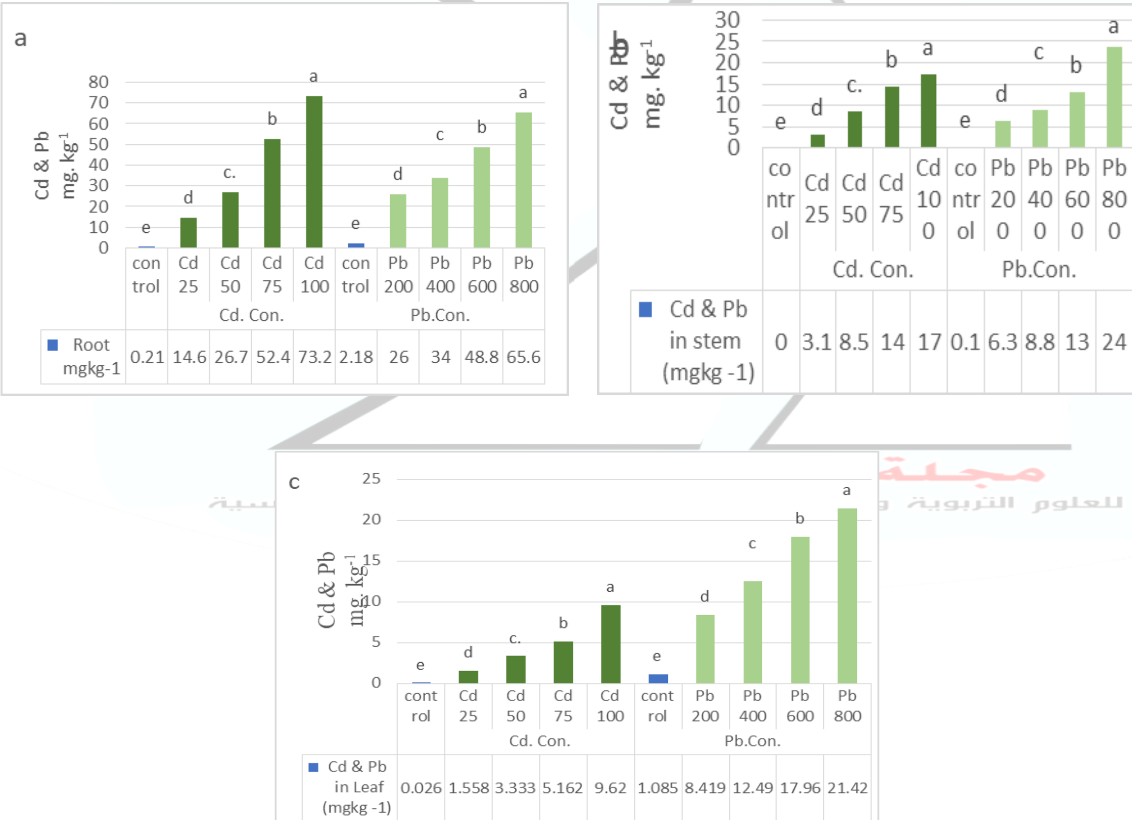

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Figure 3/Content of Cd and Pd (mgkg-1) in M.azedarach L. parts responded to soil polluted with Con. Of Cd & Pb (a for root, b for stem, & c for leaf(
*means followed with same letters for each factor are not significantly different according to Duncan Multiple range test at probability level (0.05)

4.Mechanisms and Parameters of M.azedarach L. seedlings in extraction of Cd and Pd from the soil.

a) Translocation factor (TF) of Cd and Pb in the seedlings.

The findings displayed in (figure 4) indicated that the most values of (TF) of Cd and Pb in the seedlings significantly increased with increased concentrations of these two metals in the soil. So, the biggest values of (TF) of Cd achieved (0.442) in the seedlings treated with Cd concentration of (50) mg.kg-1 dry soil compared to the smallest value reached (0.299) at the control treatment, which did not differ significantly from the its concentration (25) mg.kg-1 dry soil in the soil, as it was no significant differences observed between the (TF) of Cd in the seedlings polluted with concentrations of Cd (75 and 100) mg.kg-1dry soil. Regarding (TF) of Pb, the biggest value was (0.690) in the seedlings treated with Pb concentration of (800) mg.kg-1 dry soil compared to the smallest value reached (0.563) at the control treatment, which did not differ significantly from its concentration of (200) mg.kg-1dry soil, as it was no significant differences observed between the (TF) of Pb in the seedlings polluted with concentrations of Pb (400 and 600) mg.kg-1 dry soil in their impact on (TF). Our findings are relatively compatible with results of Qados (2017) on seedlings of acacia, eucalyptus and dams that were treated with different concentrations of Pb and Cd in the soil, the results showed that the highest value of the transfer factor (TF) for Pb and Cd in acacia seedlings was (0.41 and 0.52) and its value was (0.57 and 0.84), respectively in eucalyptus seedlings, and also, with the findings obtained by Wang et al., (2014) on seedlings of three cultivars of Salix integra (Dahongtoug, Yizhibi ,Weishanhu), the results showed that the highest value of the (TF) approached 0.05 in the three cultivars. However our results are in contrast of the results obtained by Abbasi, et al., (2017) on seedlings of Acer cappadocicum, Fraxinus excelsior and Platycladus orientalis exposed to various contaminations of Pb, where the found that the value of the (TF) decreased for all species in response with the increase of Pb concentrations in the soil. According to these results, it is noted that despite the increase in the values of (TF) of both Cd and Pb in the seedlings with the increase in the concentrations of the two metals in the soil, however it did not reach one or more than one as reported by (Li et al., 2007), this means that seedlings of M. azedarach were not enough able to transfer Cd and Pb from their root to shoot system. The effectiveness of a plant in extracting heavy metals from its root zone to its aerial parts is influenced by its growing conditions and soil, which influences the accessibility of heavy metals for absorption by the plant, the type of plant and the productivity of dry matter, where the plant is an attractive metal accumulator (Hyperaccumulator) when the value of the TF is greater than one.

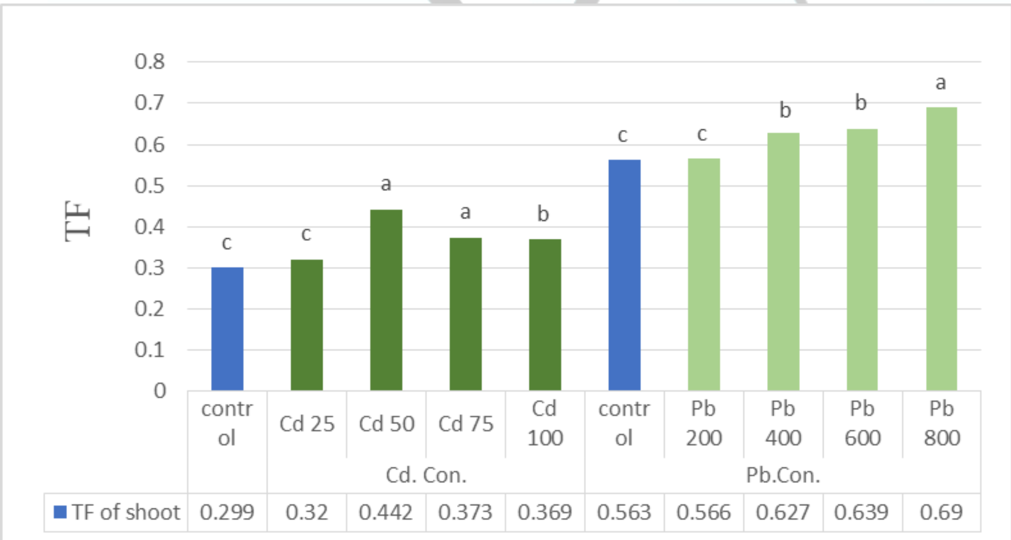

Figure 4/TF of Cd & Pb in Melia azedarach L. shoot system
*means followed with same letters for each factor are not significantly different according to Duncan Multiple range test at probability level (0.05(

b) Bioaccumulation Factor (BAF) of Cd and Pb in the seedlings of Melia azedarach L.

The findings represented in (figure 5) illustrated that (BAF) of both Cd and Pb in the seedlings at the control was significantly superior to all values of (BAF) in the seedlings treated with all concentrations of the two metals, recording the biggest value of (BAF) of Cd and Pb achieved (0.454 and 0.279) respectively at control, compared to the smallest value reached (0.187 and 0.052) in the seedlings treated with concentrations of (Cd-25 and Pd-600) mg.kg-1dry soil respectively, without any significant differences were found between (BAF) of Cd in the seedlings treated with the concentrations of Cd (50 and 75) mg.kg-1 dry soil, and with no any significant difference between the value of (BAF) of Pb in the seedlings treated with concentrations of Pb (400 and 600) mg.kg-1. Our results are relatively less than the results of Ng, et al., 2016 on Inperata cylindrica seedlings, who found that the BAF of Cd was (1.519) with the seedlings at the control treatment which was not different significantly from the concentration of Cd (15) mg.kg-1in the soil. The findings of the study are in agreement with the results obtained by Yang et al., (2020) study seeking the impacts of Pb and Cd alone and in combination on the photosynthesis of Davidia involucrate, BAF at control was more than under other levels of Cd & Pb. For Cd was 8.605 at untreated seedlings while at 30 mg.kg-1 was 0.192. At control for Pb was 0.19 while at 1000 mg.kg-1 was 0.019. Based on the study findings, which demonstrated that all (BAF) values for Cd and Pb were less than one, this means Melia azedarach seedlings are not sufficient accumulators of both metals from the soil to the aerial parts of plants. The efficacy of a plant in extracting heavy metals from soil that is contaminated to the root system and then to the above parts of the plant is dependent on its protection strategies in its root system as well as the circumstances surrounding growth and the physical, chemical, physiological, and biological features of soil that determine the accessibility of heavy metals for the absorption by the plant as well as the type of plant and its chemical, physiological, and genetic characteristics.

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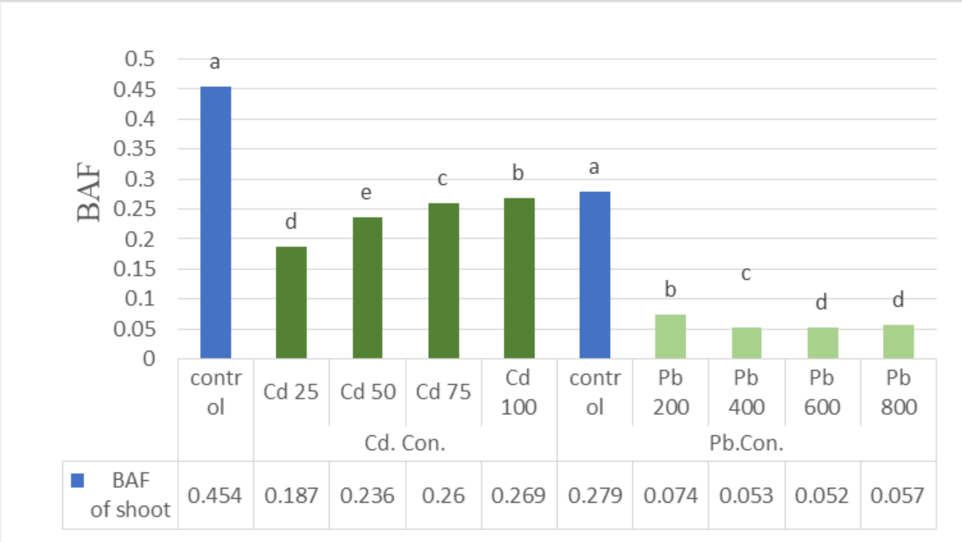


Figure 5/ BAF of Cd & pb in Melia azedarach L. shoot system
*means followed with same letters for each factor are not significantly different according to Duncan Multiple range test at probability level (0.05)

c. Bioconcentration factor (BCF) of Cd and Pb in the seedlings of Melia azedarach L.

The data represented in (figure 6) showed that the values of (BCF) of Cd and Pb in the untreated seedlings at control treatment was significantly superior to all values of (BCF) of Cd and Pb in the seedlings treated with all concentrations of the two metals, recording the biggest value of (BCF) of Cd and Pb achieved (1.520 and 0.496) respectively, compared to the smallest value reached (0.534 and 0.082) in the seedlings treated with concentrations of (Cd- 50 and Pd- 600) mg.kg-1 dry soil respectively. The values of the current study are in contrast of values obtained by El-Mahrouk et al., (2019) on seedlings of Salix mucronate that treated with various concentrations of Cd and Pb in the soil, The results showed that the (BCF) of roots achieved 0.27 at control treatment and it reached 0.6 at Cd concentrations 80 mg.kg-1 dry soil and achieved 0.48 at Pb concentrations 850 mg.kg-1 dry soil. This may be attributed to the difference in the type and physiological characteristics of trees. The value of (BCF) in the plant is determined by the sort of metal and its level in the soil, as well as the species of plant and circumstances surrounding it (Kabata-Pendiasand Pendias,1999).

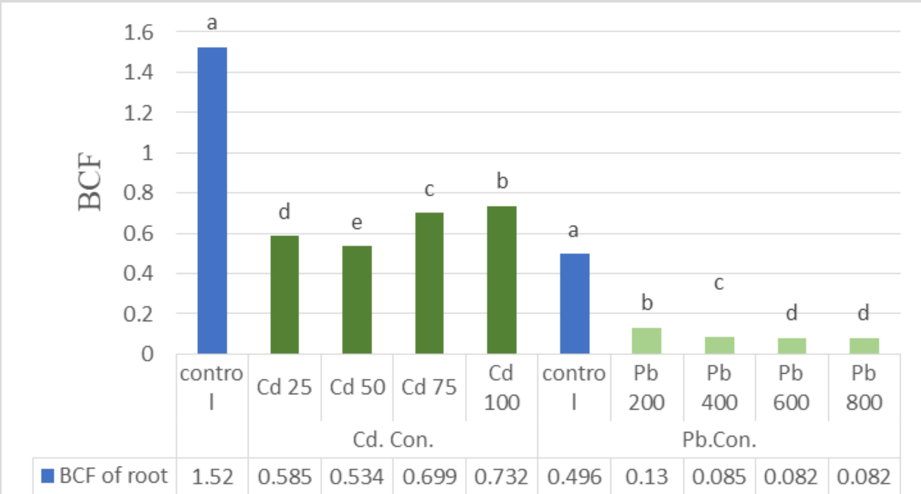
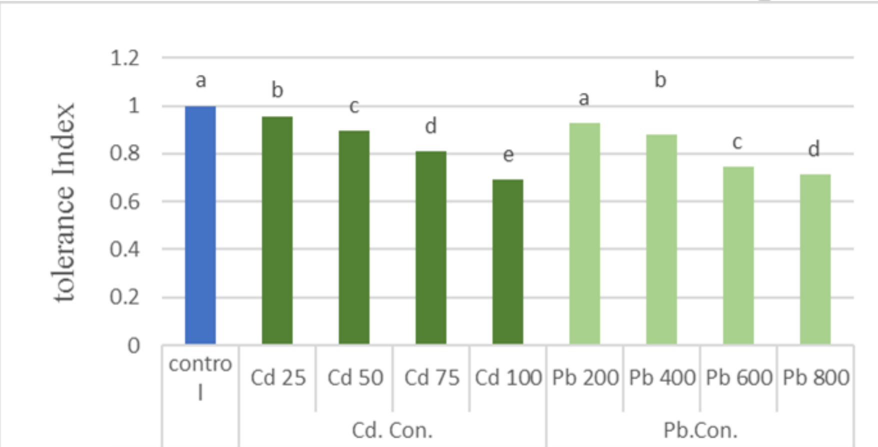


Figure 6/BCF of Cd & pb in Melia azedarach L. root system
*means followed with same letters for each factor are not significantly different according to Duncan Multiple range test at probability level (0.05(

d. Tolerance index (TI) of seedlings.

The findings displayed in (Figure 7) indicated that concentrations of both Cd and Pb significantly reduced (TI) of seedlings, and this reduction in (TI) increased with increasing concentrations of Cd and Pb in the soil. The untreated seedlings at their control treatment were significantly superior to all values of (TI) of seedlings treated with all concentrations used of the two metals, recording the greater value reached (1.000) compared to the smallest value of (TI) of seedlings reached (0.691 and 0.714) in the seedlings treated with concentrations of (Cd-100 and Pd- 800) mgkg-1dry soil respectively. The reason behind the decline in tolerant index with increasing concentrations of Cd and Pb in the soil, returns to the stress imposed by heavy metals on plant, which cuase inhibition of plant growth, reduction in plant biomass, that is depend on type of plant, and type and quantity of toxins which were absorbed in the cellular tissues of plant (Dickinson, et al., 1994 and Utmazian et al., 2007). The results of current study are consistent with the findings reported by El- Mahrouk et al., (2019) on seedlings of

Salix mucronate which showed that the value of tolerance index (TI) was achieved 0.49 in seedlings polluted by Cd concentrations 80 mgkg-1 dry soil and 0.55 in seedlings polluted by Pb concentrations 850 mgkg-1 dry soil. Abbasi, et al., (2017) in their study on seedlings of Acer cappadocicum, Fraxinus excelsior and Platycladus orientalis exposed to different concentrations of Pb, The results showed that the value of tolerance index was deceased by increasing Pb concentrations in the soil. Also, Wang et al., (2014) in their study on seedlings of three cultivars (Dahongtoug, Yizhibi ,Weishanhu) of Salix integra, the results showed that the tolerance index (TI) value in the three cultivars ranged between (62.78- 95.80)



	control	Cd 25	Cd 50	Cd 75	Cd 100	Pb 200	Pb 400	Pb 600	Pb 800
TI	1	0.957	0.896	0.811	0.691	0.928	0.879	0.745	0.714

Figure 7/ TI of Cd & Pb in Melia azedarach L.
*means followed with same letters for each factor are not significantly different according to Duncan Multiple range test at probability level (0.05)

Conclusion

Although most of the growth characteristics of Chinaberry seedlings, including biochemical traits have been affected negatively by concentrations of Cd and Pb in the soil, but they have shown their tolerance (TI) and ability to accumulate more concentrations of both Cd and Pb in their root system (BCF) than shoot system (BAC), without causing any toxicity symptoms therefore, this tree is considered suitable phytoremediator for polluted soil with Cd and Pb, The accumulation of a large amount of Cd and Pb in the root system of Chinaberry seedlings compared to their shoot system, confirm the ability of this tree to withstand stress resulting from heavy metals, by forming complexes that encapsulate heavy metals in the vacuoles, which have been identified as a detoxification mechanism in roots. Therefore, it is considered environmentally friendly thus, the fall of its leaves in the autumn season will not cause environmental risks.

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