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PHYTOREMEDIATION OF SOIL CONTAMINATION WITH SOME HEAVY METALS (NI, CD, PB) USING OLEANDER PLANT.

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ABSTRACT

A biological experiment was conducted according to a completely randomized design (CRD) in woody canopy using phytoremediation technology to reclaim soils polluted with some heavy metals (Ni, Cd, Pb) biologically by planting Oleander plant. Based on calculation of global environmental pollution indicators, with three factors and six replicates, namely soil contamination with three heavy elements: Pb, Cd, and Ni, and four combinations: Pb + Cd, Cd + Ni, Ni + Pb, and Pb + Ni + Cd. with two element levels: 0 and 120 for Lead, 0 and 10 for Cadmium, and 0 and 70 mg kg^{-1} for Nickel, using Loamy Sand soil. The coefficients were coded as follows: N, C, P, CN, NP, CP, CNP, and O. Results showed an increase in values of Bio concentration factor (BCF) of root system of Oleander plant for Nickel for treatments N, CN, CNP, and PN treatments reaching 22.93, 19.87, 18.16, and 17.78, respectively, and it decreased in rest of treatments. Highest values for Cadmium were in C, then CN, CP, and CNP treatment, reaching 3.20, 2.65, 2.37, and 2.18. Thus, Oleander plant is considered one of plants that accumulate Cd. BCF was low for Pb, values of BAC increased with increasing concentrations of available heavy metals in soil. Values of TF for Cd, Ni, and Pb are lower than value of one.

Keywords: bioreclamation, standards, plant pollution.

المعالجة النباتية للترب الملوثة ببعض العناصر الثقيلة(Ni , Cd , Pb) باستعمال نبات الدفلة.

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الخلاصة

اجريت تجربة بايلوجية وفق تصميم تام التعشية (CRD) في الظلة الخشبية باستعمال تقنية المعالجة النباتية لاستصلاح الترب الملوثة ببعض العناصر الثقيلة(Ni , Cd , Pb) ح*يويا بزراعة نبات الدفلة بالاعتماد على حساب مؤشرات التلوث البيئي العالمية, بثلاثة عوامل وستة مكررات وهي تلويث التربة بثلاثة عناصر ثقيلة هي Pb و Cd و Ni واربعة توليفات هي Pb + Cd و Ni+Cd وNi + Pb و Pb + Ni + Cd. و مستويين للعناصرهي0 و 120 للرصاص و 0 و10 للكادميوم و 0 و70 ملغم كغم$^{-1}$للنيكل باستعمال تربة ذات نسجة مزيجة رملية. ورمزت

* **This article is taken from the doctoral dissertation of the first researcher.**

المعاملات كالاتي N وC وP وCN وNP و CP وCNP و O. بينت النتائج ارتفاع قيم عامل التركيز الحيوي (BCF) للمجموع الجذري لنبات الدفلة لعنصر النيكل للمعاملات N و CN و CNP و PN بلغت 22.93 و 19.87 و 18.16 و 17.78 بالتعاقب وانخفضت في باقي المعاملات ,و كانت اعلى القيم للكادميوم في المعاملة C ثم CN و CPو CNP بلغت 3.20 و 2.65 و 2.37 و 2.18 وبذلك يعد نبات الدفلة من النباتات المراكمة للكادميوم. كانت BCF منخفضة للرصاص , زيادة قيم معامل التراكم الحيوي (BAC) مع زيادة تراكيزالعناصر الثقيلة الجاهزة في التربة انخفاض قيم معامل الانتقال الحيوي (TF) للعناصر Cd و Ni و Pb عن قيمة الواحد.

الكلمات المفتاحية: الاستصلاح الحيوي, معايير , تلوث النبات.

INTRODUCTION

Soil pollution is a physical, chemical or biological imbalance in ecosystem or its balance resulting from human activity or natural activity, followed by direct or indirect damage in general health of humans and environment, including living organisms, natural resources, and economic properties (**Harith, 2021**). Heavy metals are natural elements found in environment or food. They are called heavy due to heaviness of their atomic weight, which is equal to five times weight of water or more, meaning their density or specific gravity is more than 5 $g.cm^3$ or more (**Elmsley, 2001**).Accumulation of heavy metals in agricultural soil is a growing concern due to its close relationship with food safety, or its arrival through leaching into groundwater and surface water represented by nearby rivers and bodies of water, which may lead to potential health risks. **Al-Saffar (2016)** explained that soil near Al-Jadiriya diesel station is polluted with some heavy metals (Pb and Cd) as a result of emissions into air resulting from burning diesel fuel used in the station. **Chyad *et al.* (2022)** indicated that the discharge of hospital and factory waste into irrigation water leads to an increase in concentrations of heavy metals such as Cadmium, Lead, Manganese, and Iron in it, which are transferred to soil when used for irrigation. **Hameed & Naser (2023)** showed a rise in available concentrations of heavy metals in soils and plants passing through polluted water. Release of toxic heavy metals into environment poses a major threat to water quality and aquatic ecosystems, which puts human health at risk, heavy metals accumulate in plants and organisms that enter human food chain**,** soil pollution with heavy metals such as Pb, Cr, Cd, Ni, Cu, Zn, and Fe is one of most serious environmental problems at global level due to their long half-life and lack of decomposition **(Balali-Mood *et al*., 2021 ; Türkmen *et al.*, 2022). Naser (2017)** explained that irrigating soil with water contaminated with heavy metals causes their accumulation in soil and pollutes it. **Al-Mandalawi & Al-Anbari (2010)** confirmed, when they evaluated pollution of Diyala River, soil and plants of agricultural lands on both sides of river in Diyala Bridge area, which is irrigated with river water, with heavy metals, a high concentration of Cd in river water exceeding permissible limit of World Health Organization, concentration of Nickel in soil exceeded World Health Organization standards.

Concentrations of most heavy metals in surface layer of soil were higher than their concentrations in other layers, which indicates movement and transfer of these elements through soil layers. Concentration of lead in most plants was often high above permissible limit, reaching 1.04, 1.375, 1.8, and 1.85 mg kg^{-1} for Celery, Radish, Barley, and Clover, respectively. Therefore, increasing consumption of these contaminated plants by humans may cause health problems in future.

Sumira & Javid (2016) explained that phytoremediation is process of cleaning environment from harmful pollutants using a plant that acts as a filter that absorbs toxic elements from water and soil, removing soil and water pollutants using plants, because plant biological processes help in this process. Phytoremediation is an environmentally friendly technology that uses a biological system such as a plant that collects pollutants and removes them from ecosystem through plant roots, and its an economically inexpensive and environmentally friendly process**.** Certain types of plants are able to absorb high concentrations of pollutants present in environment and accumulate them in their tissues without showing any signs of toxicity. **Ali (2022)** stated that studies indicate that there are hundreds of types of plants accumulated and used in phytoremediation technology, including many plant families such as Poaceae, and others. Beautiful Oleander shrub (*Nerium oleander*) is a shrub that hides a deadly poisonous danger behind its beauty. It is one of poisonous and highly toxic ornamental plants. It is often planted in parks and public gardens for decorative purposes. Homes. Plant is tolerant to salinity, heat, and drought. Due to its high toxicity, it deters animals from eating it and eliminates natural pesticides. Research aims to reclaim soil contaminated with heavy metals using Bio reclamation (phytoremediation) technology by planting oleander plant.

MATERIALS AND METHODS

A potting experiment was carried out in woody canopy using Loamy Sand calcareous soil. The concentrations of heavy metals (Pb, Cd, and Ni) in the soil were estimated according to methods mentioned in **Page *et al.,* (1982)**, **Jackson (1958); Black *et al.* (1965)** (Table 1). Soil was polluted by adding solutions of three heavy metals (Pb, Cd, and Ni, prepared from $NiSO_4$, $CdSO_4$, $PbSO_4$, and four combinations: Pb + Cd, Cd + Ni, Ni + Pb, and Pb + Ni + Cd. The second factor: two levels for heavy metals: 0 and 120 for Lead, 0 and 10 for Cadmium, and 0 and 70 mg $kg^{-1}$for Ni, thus, treatment are as follows: N: treatment of adding Ni at a level of 70 mg Ni kg^{-1} soil, C: treatment adding Cd at a level of 10 mg Cd kg^{-1} soil, P treatment adding Pb at a level of 120 mg Pb kg^{-1} soil, and CN: treatment adding two elements Cd at a level 10 mg Cd kg^{-1} soil and Ni at a level of 70 mg Ni kg^{-1} soil together and NP: treatment of adding elemental Ni at a level of 70 mg Ni kg^{-1} soil and Pb at a level of 120 mg Pb kg^{-1} soil together and CP: treatment of adding elemental Cadmium at a level of 10 mg Cd kg^{-1} soil and lead at a level of 120 mg Pb kg^{-1} soil together, and CNP: Treatment of adding cadmium at a level of 10 mg Cd kg^{-1} soil, Nickel at a level of 70 mg Ni kg^{-1} soil, and Pb at a level of 120 mg Pb kg^{-1} soil together in addition to Comparative treatment O (no heavy element added to soil), so the number of experimental units became:

8 (elements and combinations) x 2 (level) x 6 (replicates) = 96 experimental units. Pots were filled with 20 kg of contaminated soil and tamped several times to obtain an apparent density close to field soil. Tap water was added in a volume within field capacity of soil and left for a week for balancing while maintaining moisture content of soil using the gravimetric method. One-year-old oleander seedlings (six-month-old young) were planted as one plant in potting plant in woody canopy, N, P, K, fertilizers were added according to fertilizer recommendation (Spray fertilization 5 gL^{-1} , this recommendation is used for citrus and ornamental trees) for solution containing NPK complex 20-20-20(N-P_2O_5-K_2O) in 5gL^{-1} was foliar applied twice in season, with a time interval of 20 days between two sprayings (**Al-Falahi & Al-Janabi, 2016**). Irrigation was done with tap water after 50% of plant's available water was exhausted by weighing pot with soil and plant based on loss of available water using gravimetric method.

Total heavy metals in soil (Pb^{2+}, Ni^{2+}, Cd^{2+}) were determined at end of experiment (240 days) after digesting soil using 4 ml of concentrated sulfuric acid and 2 ml of perchloric acid. determination was made using an atomic absorption device (AAS) and according to the method of **Quevauviller (2002)** mentioned in **BlacK (1965)**. Plant samples (the entire plant, roots, stems, and leaves separately) were taken at end of experiment, It was washed first with tap water, then with distilled water, dried air-dried, then placed in oven at a temperature of 65°C for 48 hours, then left to cool at room temperature, ground using an electric grinder and passed through a 212 micrometer sieve. A weight of 0.25 grams was taken from plant sample

digested using wet method using sulfuric and perchloric acid in a ratio of 2:1., then concentrations of heavy metals (Pb, Cd and Ni) were estimated using an atomic absorption device (AAS). Available heavy metals in soil were extracted using chelate compound DTPA, and they were determined using an atomic absorption device (AAS) and according to above method. Then these concentrations were compared with their critical concentrations in

Table (1): Some chemical and physical characteristics of study soil before planting.

Properites	Value	Units
EC 1:1	1.60	dS m^{-1}
pH 1:1	7.40	---------
Organic Matter	4.33	g Kg^{-1}
$CaCO_3$	220.15	gKg^{-1}
CEC	13.01	Cmole + Kg^{-1}
Soluble Cations and Anions	—	mmol L^{-1}
Calcium Ca^{+2}	4.10	=
Magnesium Mg^{+2}	2.66	=
Sodium Na^{+}	2.70	=
Potassium K^{+}	0.28	=
Carbonate CO_3	Nil	=
Bicarbonate HCO_3^-	1.50	=
Chloride Cl^-	9.70	=
Sulphate SO_4	2.21	=
Available Nitrogen	19.00	mg kg^{-1}
Available Phosphorus	4.40	=
Available Potassium	69.00	=
Total Lead	10.53	mg kg^{-1}
Total Cadmium	0.38	=
Total Nickel	0.54	=
Available Lead	0.20	mg kg^{-1}
Available Cadmium	0.10	=
Available Nickel	0.16	=
Sand	840.00	g Kg^{-1}
Silt	64.00	g Kg^{-1}
Clay	96.00	g Kg^{-1}
Soil Texture	Loamy Sand	

plants (global determinants), and to estimate extent of plant contamination with these elements, the following environmental pollution indicators for plants were calculated:

1- Bio Concentration Factor (BCF). (Yoon *et al*, 2006).

$$BCF = (Metal)_{Root} / (Metal)_{Soil}$$

where: BCF: Bioconcentration Factor., (Metal)Root: Concentration of the element in root part (mg kg^{-1} dry wt.of plant), (Metal)Soil: Total concentration of element in soil (mg kg^{-1}). If BCF value is greater than one, this indicates the plant's high ability to absorb and accumulate heavy metal in its tissues, but if value is less than one, this indicates the plant's inability to absorb heavy metal from soil in sufficient quantity. (**Cui *et al.*, 2007**).

2- Bio Accumulation Coefficient (BAC). (Cui *et al*., 2007)

$$BAC = (Metal)_{Shoot} / (Metal)_{Soil}$$

where BAC: bioaccumulation coefficient, (Metal)Shoot: concentration of element in vegetative part (mg kg^{-1} dry wt.of plant), (Metal)Soil: total concentration of element in the soil (mg kg^{-1}).

3- Translocation Factor (TF) (Cui *et al.*, 2007)

$$TF = (Metal)_{Leaves} / (Metal)_{Root}$$

So: TF: local transfer factor, (Metal)Leaves: concentration of element in leaves (mg kg^{-1} dry wt.of plant), Root (Metal): concentration of element in root part (mg kg^{-1} dry wt.of plant) .

RESULTS AND DISCUSSION

Heavy metals in soil at end of experiment

Total heavy metals concentration in soil

It is clear from results of the statistical analysis in Table 3 that there are significant differences between different treatments in total concentrations of Ni, Cd, and Pb in soil. It is noted that treatments in which element was added were superior compared to other treatments. Highest values for Ni were in CNP, CN, PN, and N treatments, reaching 38.54, 35.95, 31.86, and 20.93 mg Ni kg^{-1} soil. This is consistent with what was reported by Al-Awsi (2022), who showed an increase in total Ni concentrations in soil with increasing levels of Ni added to soil. Treatments in which Ni was added with another element (CN and PN), we find that differences are significant between them, CN treatment outperformed PN. This is due to the fact that Ni is more mobile in soil and its transformation from total to available concentration is faster due to speed of its movement and absorption by plants and effect of common ion, so its total concentration decreases, which leads to an increase in conversion of total Ni to available and a decrease in its quantity compared to Pb in PN treatment, which is a slow-moving element in soil, has little conversion from total to available, so total concentration of Ni remains higher.As for Cadmium, CNP, CP, CN and C treatments were superior, with total Cd concentration reaching 3.85, 3.13, 2.28 and 1.64 mg Cd kg^{-1} soil, respectively. This is consistent with what was indicated by **Talib (2023),** who showed that adding Cd and Ni to soil leads to an increase in its total concentration in soil. As for Lead, Highest concentration reached 85,210 mg kg^{-1} in the CNP treatment, then 81,19, 72,42, and 52,61 mg kg^{-1} for the CP, PN, and P treatments, respectively **(karim *et al*., 2022).**Increase in total Pb concentration in CNP treatment may be due to effect of presence of three elements simultaneously in soil, which leads to transformation of small amounts of total Lead added to soil into available form in soil due to chemical balance of soil solution. This led to Lead added to soil remaining in a precipitated or adsorbed form, since soil is calcareous, and high pH of soil leads to the deposition of heavy metals in soil, including Lead. This is consistent with what was indicated by **Farhan (2020),** who explained an increase in soil pH leads to precipitation of lead in soil in form of $Pb(OH)_2$, $Pb(PO4)_2$, and $Pb5(PO_4)OH_3$, depending on degree of soil interaction.

Table (2): Total heavy metal concentration in soil (mg kg^{-1}) for different treatments at end of experiment.

Treatment	Heavy metals (mg kg^{-1})		
	Ni	Cd	Pb
N	20.93	0.25	7.23
C	10.89	1.64	7.84
P	11.73	0.24	52.61
CN	35.95	2.28	8.13
NP	31.86	0.32	72.42
CP	11.74	3.13	81.19
CNP	38.54	3.85	85.21
O	10.52	0.23	6.70
Average	21.39	1.49	40.16
Critical limit	50.00	3.00	100.00
Treatment LSD 5%	1.13*		

Available concentration of heavy metals in soil

Results of statistical analysis in Table 3 show that there are significant differences in available concentration of heavy metals in soil at end of experiment. Highest concentrations of Nickel in treatment were CNP, then PN, then CN, and finally N, reaching 2.94, 2.70, 2.22, and 1.88 mg Ni kg^{-1} soil, this is due to the amount of Ni added to the soil, which led to an increase in its available concentration in soil. Adding several elements with Nickel leads to absorption of these elements by plant in relatively similar quantities, which leads to a larger amount of available Ni remaining in soil solution. This is consistent with what was stated **Abdel Latif (2016)**, who showed that an increase in Ni in soil due to pollution leads to an increase in available concentration of it in soil. An increase in available Cd concentration is observed in treatments to which Cd was added compared to treatments to which Cd was not added. Highest values were in CNP treatment, then CP, CN, and finally C, reaching 1.02 and 0. 93, 0.74, and 0.52 mg Cd kg^{-1} soil, respectively. This is consistent with what was indicated by **Abdel Latif (2016)**, who showed that increase in available concentrations of Cadmium in soil is directly proportional to amount Cadmium added to soil. It is also noted that concentration of available Cd is lower in case of adding Cd alone (treatment C) and this is due to its increased absorption by plant in larger quantities than if compared to adding another element with it, as in treatments CNP, CN and PN. Increasing the number of elements added to soil leads to their absorption by plant in similar quantities depending on nature of each element, which leads to a reduction in amount of Cadmium available if it was added alone. These results are consistent with what was obtained in Table 3 for total concentration of Cd in soil.

Table (3): Concentration of available heavy metals in soil (mg kg^{-1}) for different treatments at end of experiment.

Treatment	**Heavy metals (mg kg^{-1})**		
	Ni	Cd	Pb
N	1.88	0.06	0.73
C	0.21	0.52	0.92
P	0.11	0.05	1.26
CN	2.22	0.74	0.62
NP	2.70	0.08	1.78
CP	0.22	0.93	1.38
CNP	2.94	1.02	1.94
O	0.12	0.04	0.34
Average	1.30	0.43	1.12
Treatment LSD5%	0.42*		

Treatments in which Pb was added significantly outperformed the rest of treatments in significantly increasing available lead concentration in soil, values reached 1.94, 1.78, 1.38, and 1.26 mg Pb kg^{-1} soil for CNP, PN, CP, and P treatments, respectively. This increase comes from amounts of Lead added to soil, while available Pb concentrations decreased in treatments in which Pb was not added reached 0.92, 0.62, and 0.73 mg Pb kg^{-1} soil for treatments C, CN, and N, respectively, these results are consistent with what was explained by **Talib (2023)**, who explained that there is a direct relationship between concentration of element added to soil and concentration absorbed by plant as a result of increasing its availability. It is also consistent with what was indicated. This is followed by **Odeh (2018); Karim *et al*. (2022)**, who explained that adding lead to soil increases its total and available concentration according to levels of addition.

Concentration of heavy metals in plant parts

1.Roots

Results of statistical analysis in Table 4 show that there are a statistically significant differences in concentration of heavy metals in plant roots for different treatments. Treatments in which heavy metals were added outperformed other treatments. Highest values for Ni reached 35.89, then 30.680, 28.870, and 27.19 mg Ni kg^{-1} dry wt. of plant for treatments N, CN, CNP, and finally PN, respectively. The superiority of N treatment is due to the addition of Nickel alone to soil and that plant absorbed largest amount of it, then CN treatment in which Nickel was added with Cadmium, as speed of movement of Cadmium in soil leads to an increase in its absorption, then Nickel, while concentrations absorbed in CNP treatment were three elements (Cd, Ni, and Pb) are relatively close together, so absorption of Ni is less,this is consistent with what was indicated by **Talib (2023),** who showed that growing plants in soil contaminated with heavy metals leads to increased absorption of these elements by roots and then to rest of plant parts.As for Cadmium, treatment C excelled by having highest concentration of 3.960 mg Cd kg^{-1} dry wt.of plant, this was followed by treatments to which cadmium was added along with other elements. Treatments CN followed, then CP and CNP, and the concentrations reached 3.49, 3.20, and 2.88 mg Cd kg^{-1}. dry wt.of plant.

Increase in concentration of Cd in these treatments comes from Cd added to them. Treatment C was the first because of presence of Cd alone and its increased absorption. As for the treatments to which Cd was added with other elements, CN treatment came second. This is because Ni is a mobile element in soil and therefore its absorption increases with Cd compared with slow-moving Pb in soil added in CP treatment, while the CNP treatment contained three elements, which leads to absorption of other elements along with Cd and thus its concentration in root decreases.

Table (4): Concentration of heavy metals in roots (mg kg^{-1} dry plant) for different treatments at end of experiment.

Treatment	**Heavy metals (mg kg^{-1} dry plant)**		
	Ni	**Cd**	**Pb**
N	35.89	0.32	2.80
C	3.48	3.96	2.12
P	3.26	0.34	39.49
CN	30.68	3.49	2.10
NP	27.19	0.31	25.25
CP	3.39	3.20	29.54
CNP	28.87	2.88	23.14
O	3.64	0.35	2.94
Average	17.05	1.85	15.92
Treatment LSD5%	1.01*		

These results are consistent with what was indicated by **Wang *et al.* (2012)**, who showed that Plants have ability to absorb Cd stabilized with Iron and Manganese oxides in soil, and their absorption is not limited to Cd dissolved in soil solution. As for Pb, treatment P, then CP, PN, and CNP outperformed the rest treatments, as concentration of Pb in root reached 39.49, 29.54, 25.25, and 23.14 mg Cd kg^{-1} dry wt.of plant. This is attributed to additions of Pb to soil, which Pb to an increase in availability of Pb and increased absorption by plants, This is consistent with what was stated by **Talib (2023)**, who showed that plants growing in soil contaminated with heavy elements have ability to absorb these elements from soil and accumulate them in soil. Root system of plant then moves to other parts of plant. Element added with Pb in some treatments significantly affected concentration of Pb in root, and this depended on availability and movement of element accompanying Pb. Nickel was highly mobile in soil and more concentrated than Cd, so its absorption increased in PN treatment at expense of Pb compared to CP treatment in which absorption of Pb increased over Cd.

2. Stems

Results of statistical analysis in Table 5 show that there are significant differences in concentration of Nickel in stem for different treatments. Highest concentrations in treatment were N, then CN, CNP, and PN, reaching 8.52, 6.45, 5.28, and 4.95 mg kg^{-1} dry wt. plant for above treatments, respectively. This is consistent with what was found by **Chen *et.al.* (2010), Odeh & Nasser (2018)** who showed that increasing concentration of heavy metals in soil increases their concentration in plant. This is also consistent with what **Al-Awsi (2022)** mentioned that Oleander plant is a Ni-accumulating plant. Highest concentrations of Cd in treatments C, CN, CP, and CNP were 1.96, 1.84, 1.71, and 1.45 mg Cd kg^{-1} dry wt.plant for above treatments, respectively. concentration of Pb in root reached 39.49, 29.54, 25.25, and 23.14 mg Pb kg^{-1} dry matter.

Table (5): Concentration of heavy metals in stem (mg kg^{-1} dry wt.plant) for different treatments at end of experiment.

Treatment	**Heavy metal (mg kg^{-1} dry wt.plant)**		
	Ni	Cd	Pb
N	8.52	0.28	0.59
C	0.74	1.96	0.51
P	0.68	0.21	13.46
CN	6.45	1.84	0.47
NP	4.95	0.16	7.18
CP	0.71	1.71	8.79
CNP	5.28	1.45	6.32
O	0.81	0.22	0.73
Average	3.51	0.97	11.98
Treatment LSD5%	0.54*		

This is attributed to additions of Pb to soil, which Pb to an increase in availability of Pb and increased absorption by plants.This is consistent with what was stated by **Talib (2023),** who showed that plants growing in soil contaminated with heavy metals have the ability to absorb these elements from soil and accumulate them in root system of plant and then move to other parts of plant.

3.Leaves

Results of statistical analysis in Table 6 show that there are significant differences in concentration of Nickel in leaves for different treatments. Concentration of Ni in leaves increased, reaching 22.93, 19.87, 18.16, and 17.78 mg Cd kg^{-1} dry wt. plant for treatments N, CN, CNP, and PN, respectively. These concentrations were consistent with concentrations of Ni in roots and stem of plant, and this indicates movement and transfer of Ni within plant from roots to stem and leaves, this is consistent with what was found by Chen *et al.* (2010) who showed that increasing concentration of heavy metals in soil increases their concentration in plant. The agreement of results in concentrations of Ni between roots, stem and leaves indicates that Ni is a mobile element within plant and that it is transferred from roots to papers and this is in line with what **Odeh & Nasser (2018**) who showed that increased absorption of heavy metals by roots leads to their transport and accumulation in upper part of plant, and showed that Ni is mobile within plant and moves to leaves.

Treatments in which Cd was added outperformed other treatments in increasing Cd concentration in leaves, as it reached 2.50, 1.83, 1.64, and 1.49 mg Cd kg^{-1} dry wt. plant for C, CN, CP, and CNP treatments, respectively, while these concentrations were consistent with Ni concentrations in roots and stem for plant, this indicates movement and transfer of Cd within plant from roots to stem and leaves. It is noted that Cd concentration increased in leaves for O treatment compared to above treatments, this comes in same increase in root and stem of this treatment, which was transferred to leaves. This is consistent with what was indicated by **Odeh & Nasser (2018) and Al-Awsi (2022)** that increasing level of Cd in plants growing in soil contaminated with Cd increases its absorption and accumulation in plant tissues.

Table (6): Concentration of heavy metals in leaves (mg kg^{-1} dry wt. plant) for different treatments at end of experiment.

Treatment	**Heavy metal (mg kg^{-1} dry wt. plant)**		
	Ni	Cd	Pb
N	1.71	1.28	0.38
C	0.31	2.41	0.27
P	0.27	1.41	0.75
CN	0.96	1.53	0.25
NP	0.70	0.96	0.40
CP	0.28	1.02	0.31
CNP	0.80	0.74	0.27
O	0.34	1.52	0.43
Average	0.67	1.36	0.38
Treatment LSD5%	0.15*		

When comparing concentration of Cd in plant (total root, stem, and leaves) with global permissible concentrations of Food and Agriculture Organization of International Food and Agriculture Organization and World Health Organization **(WHO, FAO,2007),** which amount to 0.20 mg Cd kg^{-1} dry wt. plant, it becomes clear that all concentrations and in various parts of plant it exceeded the permissible limits for all treatments, and no symptoms of poisoning or lack of growth appeared. Therefore, Oleander plant is considered one of plants that accumulate Cadmium. As for Pb, highest concentrations were in P, PN, N, and CP treatments, reaching 0.75, 0.40, 0.38, and 0.31 mg pb kg^{-1} dry wt. plant, these results are consistent with concentrations of Pb in roots and leaves and with what was stated by **Garcia *et al*. (2004),** who showed that direct increase in concentrations of pollutant elements in plant tissues is directly proportional to increase in their concentration in soil, as available and absorbed elements increase. When comparing Pb concentrations in different parts of plant, we find that highest concentrations were in root, then leaves, and finally stem. This is an indication that Pb is a slow-moving element within plant, and its concentration and accumulation in plant roots increases, these results are consistent with what was indicated by **Farhan (2020),** who showed that concentration of Pb is higher in root system of plant compared to shoot system, and that Pb is slow to move within plant. When comparing concentration of Pb in different plant parts, we find that all concentrations exceeded internationally permissible limits set by Food and Agriculture Organization and World Health Organization **(WHO, FAO,2007)** amounting to 5 mg pb kg^{-1} dry wt. plant, and no symptoms of poisoning or decreased growth appeared. Therefore, it is considered a plant. Oleander is one of plants that accumulate Pb, and this is what was indicated by **Al-Awsi (2022)**; **Zaki (2020)**.

Standards for plant contamination with heavy metals

1-Bio Contamination Factor (BCF)

Results of statistical analysis of Table 7 show that there are significant differences in values of Contamination factor for heavy metals for Oleander plant to all treatments. Highest values for Ni in N, CN, CNP, and PN treatments were 22.93, 19.87, 18.16, and 17.78, respectively. It is noted from above that factor values for treatments in which Ni and Cd are present are greater than values of treatments in which Pb is present, this may be attributed to fact that Cd and Ni are more mobile in soil than Pb, which leads to an increase in their absorption by plant roots.

Table (7): Contamination factor (BCF) for heavy metals for different treatments.

Treatment	Heavy metals		
	Ni	Cd	Pb
N	22.93	0.27	2.29
C	2.86	3.20	1.90
P	2.64	0.29	27.13
CN	19.87	2.65	1.56
NP	17.78	0.25	19.42
CP	2.76	2.37	23.30
CNP	18.16	2.18	17.80
O	3.19	0.31	2.50
Average	11.27	1.44	11.98
Treatment LSD5%	0.75*		

and this is consistent with What was indicated by **Odeh and Nasser (2018),** who showed that Ni is a mobile element in soil and plants. Value exceeded one, which indicates that Oleander plant has a high ability to absorb and accumulate Ni when added alone, these results are consistent with findings of **Al-Awsi (2022),** which showed that Oleander plant is accumulate Ni

As for cadmium, statistically significant differences were found in values of BCF-Cd for different time periods, as highest values were in treatment C, then CN, CP, and CNP, reaching 3.20, 2.65, 2.37, and 2.18, which exceeded value of one. Therefore, Oleander plant is aplant has a high ability to absorb Cd and adapt to it without causing damage or poor growth in plant, this is consistent with what was indicated by **Talib (2023)** , who showed that increasing size and weight of plant's root and shoot system with progression of time causes an increase in absorption and accumulation of Cd in plant tissues , these results are consistent with findings of **Al-Osi (2022),** who indicated that Oleander plant is accumulate Cadmium.

Treatments varied in their values with respect to this factor for Pb and treatment in which Pb was added alone (P) was superior to rest of treatments, as value reached 0.47 compared to other treatments, which are P, CP, PN, and CNP, values of which reached 27.13, 23.30, and 19.42. 17.80 sequentially. It decreased in other transactions, but all of them exceeded value of one. Thus, Oleander plant is considered that has a high ability to absorb Pb and adapt to it without causing damage or weakening plant's growth.

2. Bio Accumulation Coefficient (BAC)

Results of statistical analysis of Table 8 indicate that there are statistically significant differences in values of bioaccumulation coefficient of heavy metals for treatments. However, all values did not exceed one, so plant is considered a poor absorber of Ni, this may be due to low concentrations of Ni added to soil or deposition of Ni in soil due to Increasing pH value of calcaerous soil, this is consistent with what was found by **Farhan (2020),** who showed that Nickel deposition increases in soil with an increase in value of soil reaction degree, due to its deposition or adsorption on surfaces of soil particles..

Table (8): Bioaccumulation coefficient (BAC) for heavy metals for different treatments.

Treatment	Heavy metals		
	Ni	Cd	Pb
N	0.40	1.120	0.08
C	0.06	1.195	0.06
P	0.05	0.875	0.25
CN	0.20	0.807	0.06
NP	0.12	0.500	0.12
CP	0.06	0.546	0.08
CNP	0.14	0.376	0.07
O	0.17	0.956	0.10
Average	0.15	0.797	0.10
Treatment LSD5%	0.03*		

Highest values for Cd were 1.19 and 1.12 in treatments C and N, which differed significantly from the rest treatments, exceeding value of one, thus, Oleander plant accumulated Cadmium,this is consistent with what was found by **Al-Awsi (2022),** who showed that Oleander plant is accumulate Cadmium. The coefficient values for Pb did not exceed value of one, this may be due to small amount of it added to soil, its slow movement in soil, or transformation of available form of it into precipitated or adsorbed due to calcareous soil conditions.

3. Translocation factor (TF)

Results of statistical analysis of Table 9 show that there are statistically significant differences in values of translocation coefficient for heavy mrtals for different treatments. However, all values did not exceed value of one, thus, site transfer of Ni from roots to leaves is weak and this is due to lack of absorption of it by plant due to lack of the amount of it added to soil. Regarding Cadmium, results show that all values did not exceed one, and this indicates a weak transfer process of Cd into plant, this may be attributed to small amount already present in soil with added amount of Cd and its lack of availability due to calcaerous soil conditions, this is consistent with what **Farhan (2020)** showed that increasing degree of soil

Table (9): Translocation factor (TF) for heavy metals for different treatments.

Treatment	**Heavy metals**		
	Ni	Cd	Pb
N	0.63	0.84	0.81
C	0.83	0.80	0.89
P	0.80	0.85	0.68
CN	0.64	0.75	0.73
NP	0.63	0.80	0.75
CP	0.81	0.74	0.77
CNP	0.62	0.75	0.77
O	0.87	0.88	0.85
Average	0.73	0.80	0.78
Treatment LSD5%	0.05*		

interaction and influence of carbonate minerals in calcareous soils leads to precipitation of Cadmium in soil in form of Cadmium carbonate ($CdCO_3$), which reduces its availability in soil **(Tahervand & Jalali, 2016**). It is also noted for Pb that all values are less than one, thus, the process of local transfer of Pb into plant is light, this may be attributed to fact that Pb is a slow-moving within plant, which leads to an increase in its accumulation in roots and a decrease in its transfer to shoot. These results are consistent with what was indicated by mechanism **Talib (2023)** who showed that Pb is slow to move from roots to other parts of plant, as it is strongly linked to root cells Pb is slow to move inside plant because it is a semi-mobile element in plant. because of high atomic weight.

CONCLUSIONS

1- High bioconcentration factor (BCF) values for root system of Oleander plant for Ni, Cd and low for Pb. This indicates high ability of Oleander plant to absorb and accumulate Nickel and Cadmium in its tissues, and thus it is considered accumulateplant for heavy metals.

2- Increasing values of bioaccumulation coefficient (BAC) with increasing concentrations of heavy metals in soil. This indicates an increase in absorption of heavy metals by Oleander plant with an increase in their concentrations in soil.

3- Values of biotransfer factor (TF) for Cd, Ni, and Pb are lower than one, and this indicates weak transfer of heavy metals from roots to leaves.

RECOMMENDATIONS

1- Using Oleander plant in bioreclamation technique for soils contaminated with heavy metals, as it is a plant that accumulates heavy metals, is environmentally friendly, and is economically inexpensive.

2- Do not approach it as it is a poisonous plant.

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