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A Comparison of Growth Response and Phytoremediation Ability of Some Woody Trees Grown under Waste Water Irrigation

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Abstract: A pot experiment was carried out at the nursery of Timber Trees and Forestry Dep., Hort.Res. Inst., A.R.C., Egypt during 2018/2019 and 2019/2020 in a sandy loamy soil on four woody trees seedlings (*Albizia lebbek*, *Dalbergia sissoo, Eucalyptus camaldulensis and Taxodium distichum*) to investigate their growth and chemical composition under wastewater irrigation. The obtained results showed a variable response in all growth parameters, total chlorophylls, total sugars and N, P and K % among the studied seedlings. On the other hand, seedling showed heavy metals accumulation (Cd, Co, Cr, Cu, Fe, Mn, Ni, P b and Zn ppm). This accumulation was more pronounced in the roots than stem and leaves except of Zn which recorded more accumulation in the leaves while Ni and Pb accumulated more in stem in all plants. Finally, this research showed superiority to *Albizia lebbek* followed by *Eucalyptus camaldulensis,* then *Dalbergia sissoo* seedlings as a phytoremediator agent while *Taxodium distichum* recorded the lowest effective seedling in this work.

Key words: Heavy metals · Waste water · Woody trees · *Albizia lebbek* · *Dalbergia sissoo* · *Eucalyptus camaldulensis and Taxodium distichum*

INTRODUCTION

Water is becoming increasing limiting resource and therefore studies needed to investigate untraditional ways to meet the increasing demand for tap water worldwide. In Egypt, water is becoming a scarce resource to consider any source of water, which might be used economically and effectively to promote further development. Irrigation of forest trees with sewage water for fuel and timber production is an approach which helps to overcome health hazarded associated with sewage forming [1]. Now, Egypt is facing a wide range of new projects aiming at expanding the green stretch in deserts by introducing forest plantation projects using treated sewage water to produce timber trees of high economic value [2].

Phytoremediation can be used to remove heavy metals from soil using some plants ability to uptake metals which are essential for plant growth (Fe, Mn, Zn, Cu, Mg, Mo and Ni), or some metals with unknown biological function (Cd, Cr, Pb, Co, Ag, Se and Hg) [3].

Although some of these heavy metals (Mn, Cu, Ni, Zn and Co) are necessary for plant growth and may correct nutrients deficiency, high concentrations of these metals could adversely affect the physiological performance of growing plants [4].

Woody trees represent an excellent way to store minerals because of rapid growth, high biomass, widespread roots and little impact on human health [5]. The tree species differ in their ability to get rid of heavy metals as mentioned by Yang *et al*. [6].

Albizia lebbeck (L.) Benth belongs to family Fabaceae, it is a multipurpose tree for semiarid regions. *A. lebbeck* has been widely distributed around the tropics and mainly planted as a shade tree [7]. It is used in medicine in different purposes. Its wood is dense and used for making cabinet timber and also some types of furnitures.

Dalbergia sissoo, belongs to family Fabaceae and is one of the most useful timber species. It is used for high-quality furniture, cabinets, decorative, veneers,

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marine and aircraft grade plywood, ornamental turnery, carving, engraving, tool handle and sporting goods. Its root wood is used for tobacco pipes. In village industry, *D. sissoo* is popular for doors and windows. Oil obtained from the seeds is used to cure skin diseases. It is used as a wind break in mango, coffee and tea plantation. The tree nodulates, it therefore improves soil fertility [8].

*Eucalyptu*s is a large genus of aromatic trees belongs to family myrtaceae. *E. camaldulensis* species used for many purposes including forestry, forest products and in ornamental plantings as well as in arts and crafts. Its leaves contain oil glands which produce oils, employed in medicine, cosmetic and pharmaceutical industries [9]. *Eucalyptus* species are used as fire wood for the production of mine wood and in the fight against erosion [10].

Taxodium distichum (bald cypress) is a deciduous conifer in the family taxodiaceae. It is native to the South Eastern United states. This tree is suitable for cultivation in light (sandy), medium (loamy) and heavy (clay) soils and can grow in very alkaline and saline soil [11]. It can tolerate atmospheric pollution. The timber is valuable for building constructions, fence posts, planking in boat, river piling, door, blind flooring shingles and garden boxes [12].

The objective of this study to investigate the effect of using secondary treated wastewater irrigation on the growth and chemical composition of four woody trees seedlings, (*Albizia lebbek*, *Dalbergia sissoo, Eucalyptus camaldulensis and Taxodium distichum)* and their performance to uptake heavy metals from soil and water.

MATERIAL AND METHODS

The present study was carried out at the nursery of Timber Trees and Forestry Dep., Hort.Res. Inst., A.R.C., Egypt during2018/2019 and 2019/2020 to investigate the effect of using secondary treated wastewater irrigation on the growth and chemical composition of four woody trees seedlings, (*Albizia lebbek*, *Dalbergia sissoo, Eucalyptus camaldulensis and Taxodium distichum)* grown in a sandy loamy soil and their performance to uptake heavy metals from soil and water. The physical and chemical analysis of the used soil are shown in Table (1) according to Page *et al.* [13].

One year old seedlings of all species averaged 30 cm in height and 3.0 mm in diameter (at 5 cm from the soil surface). The seedlings were individually planted on 1st of March 2018 and 2019 in pots (30 cm height and 25 cm diameter filled with 12 kg of sandy loamy soil). The seedlings were obtained from a private farm at El -Qanater El-Khayria., Qalioubia governorate, 20-Km northwest of Cairo.

All seedlings were irrigated with tap water for a month, after that the treatment with wastewater was started. Secondary treated wastewater used for irrigation was taken from sewage effluent treatment station at 6 th October City, Giza. The analysis of the used water in the experiment is shown in Table (1).

Table 1: Physical and chemical analysis of the the used soil and water in the experiment

Parameters	Chemical analysis of the used soil	Chemical analysis of secondary treated wastewater
Practical size distribution		
Sand%	87.00	
Silt%	7.80	
Clay%	5.20	
Soil texture	Sandy loam	
pH	7.40	7.8 0
E.C dSm^{-1}	0.87	1.55
Soluble cations meq/l		
Ca^{+}	3.20	3.65
Mg^{+}	1.54	2.35
K^{+}	0.96	0.80
Na^{+}	1.8 9	3.70
Soluble anion meq/l		
CO_{-3}	-	-
HCO_3	2.55	4.60
Cl^{-}	2.45	3.90
SO_4	2.59	2.40
D.O mg/l	-	2.40
BOD mg/l	-	10 0
COD mg/l	-	220.0
TSSmg/l	-	1890
N ppm	8.12	12.11
P ppm	1.20	3.45
Total heavy metals (ppm)		
Cd	n.d	0.01
Cu	0.80	0.20
Mn	1.30	0.18
Ni	1.15	0.03
Pb	2.11	1.13
Zn	0.78	1.11
Fe	2.88	1.70
Co	Tr	0.037
Cr	0.17	0.001

DO (dissolved oxygen), BOD (biochemical oxygen demand), COD (chemical oxygen demand) and TSS(Total suspended solids)

All seedlings were irrigated to the field capacity to standardize the irrigation rate, three times weekly in summer and twice weekly in winter and each seedling species comprised 30 seedlings arranged in three rows and each row included 10 seedlings.

Plant Sampling and Preparation: At the end of March of each season, three seedlings from each tree species (one seedling from each row) were chosen randomly to determine the following parameters:

Vegetative Growth: Seedling height, root length and stem diameter (cm), fresh and dry weights of leaves, stem and roots (g/plant) were determined.

The dry weight of each sample was determined after drying the samples in an oven at 70°C till a constant weight.

Chemical Composition: The following chemical composition were determined in leaves, stem and roots.

- Nitrogen content was determined by Nessler method according to A.O.A.C. [14].
- Phosphorous content determination was adopted colorimetrically using the chlorostannous reduced molybdophosphoric blue colour method according to King [15].
- Potassium content was determined using the Flame Photometric method according to Piper [16].
- Total sugars in leaves were determined using phenol sulphuric acid reagent according to Dubois *et al*. [17].
- Total chlorophylls in leaves were determined with dimethyl formamide as described by Mornai [18].
- Heavy metals (Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn) in leaves, stem and roots were extracted by DTPA and measured in the solution by Atomic Absorption Spectrophotometer [19].

Layout of Experiment and Statistical Analysis: One year old seedlings of all species averaged 30 cm in height and 3.0 mm in diameter. All seedling were irrigated to the field capacity to standardize the irrigation rate and each seedling species comprised 30 seedlings (arranged in three replicats and each replicat included 10 seedlings. Three seedlings from each species were chosen with completely randomized design to determine the growth parameters. Data subjected to analysis of variance method and means were performed by the L.S.D. test at 5% level as described by Snedecor and Cochran, [20].

RESULTS AND DISCUSSION

Vegetative Growth: Concerning the effect of waste water irrigation on seedling height, root length and stem diameter (cm) data in Table (2) showed that, in the first season there was an increased of the previous parameters with predominance of *Albizia lebbek in* seedling height and stem diameters (195.00 and 2.90cm) followed by *Dalbergia sissoo* which recorded (188.00 and2.52cm) and *Eucalyptus camaldulensis* (178.00 and 2.30 cm) while, *Taxodium distichum* seedling recorded the lowest values (90.00 and 0.63cm). As regarding root length the seedling of *Eucalyptus camaldulensis* recorded the longest roots (65.0cm) followed by *Albizia lebbek and Dalbergia sissoo* (59.0 and 56.67cm) while *Taxodium distichum* formed the shortest roots (33.00 cm). Similar results obtained in the second season. From the results in both seasons, there were significant differences among all studied seedlings in all parameters.

On the other hand, about the effect of wastewater irrigation on fresh and dry weights of leaves, stem and roots of the studied seedlings Tables (3 and 4) showed significant differences among tree species in these characters as, *Albizia lebbek* seedlings recorded the highest fresh weight values of these parameters giving (158.30, 246.00 and 230.00g/plant) and (52.70, 83.00 and 76.00g/plant) for D.W of leaves, stem and roots, respectively, followed by *Dalbergia sissoo* while recorded (130.00, 218 .00 and 220.00g/plant) as regard F.W and (44.20, 75.00 and 73.60 g/plant) as regard D.W, while *Eucalyptus camaldulensis* seedlings recording (125.00, 151.00 and 185.00g/plant F.W) and (42.00, 53.97 and 62.0g/plant D.W). The seedling of *Taxodium distichum* seedling continued to record the lowest values in all growth parameters. Similar trends observed in the second season.

From the previous results, it can be concluded that, the use of treated wastewater in irrigation of *Albizia lebbek*, *Dalbergia sissoo, Eucalyptus camaldulensis* and *Taxodium distichum* seedlings caused a variable response in growth parameters in all of these seedlings. These results are in agreement with Meczek *et al*. [21] on *Salix alba* and *Salix viminalis* and Alex *et al.* [22] on *Salix mucronata* plants. Many researchers found that sewage effluent had a stimulatory effect on vegetative growth of some trees, provided the soil with plant nutrients and improved the soil physical characteristics, that reflected on the growth by enhancing the cell elongation and division Hassan [23] on *Acacia saligna* and *Leucaena leucocephala*; Bhati and Singh [24]

Table 2: Effect of secondary treated wastewater irrigation on seedling height, root length and stem diameter (cm) of *Albizia lebbek*, *Dalbergia sissoo, Eucalyptus camaldulensis* and *Taxodium distichum* during 2018/2019 and 2019/2020

	Seedling height (cm)		Root length (cm)		Stem diameter (cm)	
Tree species	1st	2nd	1st	2nd	1st	2nd
Albizia lebbek	195.00	190.00	59.00	55.00	2.90	2.55
Dalbergia sissoo	188.00	185.00	56.67	49.00	2.52	2.37
Eucalyptus camaldulensis	178.00	170.00	65.00	60.00	2.30	2.22
Taxodium distichum	90.00	95.00	33.00	40.00	0.63	0.55
L.S.D at (0.05)	2.39	2.27	1.03	1.06	0.15	0.14

Table 3: Effect of secondary treated wastewater irrigation on fresh weights of leaves, stem and roots (g/plant) of *Albizia lebbek*, *Dalbergia sissoo, Eucalyptus camaldulensis and Taxodium distichum* seedlings during 2018/2019 and 2019/2020

	F.W. of leaves		F.W. of stem		F.W. of roots	
Tree species	1st	2nd	1st	2nd	1st	2nd
Albizia lebbek	158.30	152.00	246.00	227.00	230.00	223.00
Dalbergia sissoo	130.00	125.00	218.00	215.00	220.00	200.00
Eucalyptus camaldules	125.00	120.00	151.00	145.00	185.00	175.00
Taxodium distichum	25.00	27.00	50.00	55.00	35.00	42.00
L.S.D at (0.05)	2.45	2.33	1.97	1.89	1.85	1.87

Table 4: Effect of secondary treated wastewater irrigation on dry weights of leaves, stem and roots (g/plant) of *Albizia lebbek*, *Dalbergia sissoo*, *Eucalyptus camaldulensis and Taxodium distichum* seedlings during 2018/2019 and 2019/2020

Tree species	D.W of leaves		D.W. of stem		D.W. of roots	
Season	1st	2nd	1st	2nd	1st	2nd
Albizia lebbek	52.70	51.70	83.00	77.60	76.00	73.00
Dalbergia sisso	44.20	42.00	75.00	71.00	73.60	66.70
Eucalyptus camaldules	42.00	39.2 0	53.97	48.00	62.00	59.20
Taxodium distichum	8.40	9.11	16.70	18.70	11.90	13.50
L.S.D at (0.05)	0.23	0.21	0.19	0.20	0.77	0.76

on *Eucalyptus camaldulensis*; Singh and Bhati [1] *on Dalbergia sisso* and Ali *et al.* [25] on *Tipuana speciosa*. Also, many investigators, found that, the role of phytoremediation was cleared by encouraging the uptake of some elements by plants such as Zn which is essential for the normal growth as coenzymes, in addition, the role of some elements especially N, P and K in different physiological processes of metabolites that enhance cell division and elongation in the cambium zone, on willow (*Salix sp)* [26].

Chemical Composition

Total Chlorophylls and Total Sugars: As regard wastewater irrigation effects on the total chlorophylls and total sugars data in Table (5) showed that *Dalbergia sissoo* recorded the highest content (0.70 and 2.62 mg/g F.w respectively) followed by *Albizia lebbek* which contains (0.64and 2.37mg/g F.w respectively), then *Eucalyptus camaldulensis* (0.49and 2.25mg/g F.w), meanwhile the *Taxodium distichum* seedlings still recording the lowest values (0.37and 1.36 mg/g F.w) in the first season. On the other hand, similar results were obtained in the second one.

Using of wastewater caused an increase in the content of total chlorophylls and total sugars in all of the studied plants .The increase of pigments concentration in the leaves of the plants irrigated with treated sewage water may be due to the higher concentrations of nitrogen, magnesium, iron and zinc in the sewage water [27]. Similar results obtained by Zaki and Shaaban [28] on sunflower. Also, the obtained results were in harmony with the findings of Al- Atrach [29] on some timber trees, who mentioned that, the increase in the total carbohydrates may be due to the increase of total chlorophyll content in leaves of seedlings irrigated with municipal wastewater which enhanced photosynthetic rate and increased the accumulation of carbohydrate in shoots.

2-N, P and K %: Concerning N, P and K% in seedlings organs grown under wastewater irrigation, data in Table (6) showed that, there were differences among seedling species and organs. The highest value o f N, P and K % were recorded in leaves > stem> roots in all tested seedlings. The nitrogen content was the highest in *Dalbergia sissoo* recording (2.42% in leaves, 1.29 %

Table 5: Effect of secondary treated wastewater irrigation on total chlorophylls and total sugars (mg/g F.W) of *Albizia lebbek*, *Dalbergia sissoo, Eucalyptus camaldulensis and Taxodium distichum* seedlings during 2018/2019 and 2019/2020

	Total chlorophylls (mg/g F.W)		Total sugars (mg/g F.W)	
Tree species	1st	2nd	1st	2nd
Albizia lebbek	0. 64	0.67	2.37	2.45
Dalbergia sissoo	0.70	0.69	2.62	2.84
Eucalyptus camaldulensis	0.49	0.51	2.25	2.37
Taxodium distichum	0.37	0.41	1.36	1.26

Table 6: Effect of secondary treated wastewater irrigation on N, P and K.% in leaves, stem and roots of *Albizia lebbek*, *Dalbergia sissoo, Eucalyptus camaldulensis and Taxodium distichum* seedlings after two years from establishment

	Leaves			Stem			Roots		
Tree species	N%	P%	K%	N%	P%	K%	N%	P%	K%
Albizia lebbek	2.22	0.27	1.35	1.24	0.16	1.14	0.95	0.13	1.12
Dalbergia sissoo	2.42	0.29	1.65	1.29	0.19	1.36	0.98	0.16	1.24
Eucalyptus camaldulensis	2.17	0.21	1.23	1.17	0.14	1.12	0.78	0.12	1.08
Taxodium distichum	1.35	0.19	0.75	1.02	0.13	0.67	0.77	0.11	0.53

in stem and 0.98% in roots) followed by *Albizia lebbek* (2.22 %in leaves, 1.24 %in stem and0.95% in roots), then *Eucalyptus camaldulensis* (2.17% in leaves, 1.17% in stem and 0.78 % in roots) while *Taxodium distichum* seedlings recorded the lowest values of N, P and K contents (1.35% in leaves, 1.0 2% in stem and 0.7 7% in roots).

On the other hand, about phosphorus content *Dalbergia sissoo* recorded the highest values in the different plant parts (0.29%in leaves, 0.19%in stem and 0.16% in roots) followed by *Albizia lebbek* (0.27% in leaves, 0.16% in stem and 0.13% in roots) then *Eucalyptus camaldulensis* (0.21%in leaves, 0.14%in stem and 0.12% in roots) while *Taxodium distichum* recorded the lowest values of these element.

As regard potassium content *Dalbergia sissoo* still recording the highest values (1.65%in leaves, 1.36%in stem and 1.24%in roots) followed by *Albizia lebbek*(1.35 in leaves*,* 1.1 4 %in stem and 1.12%in roots) then *Eucalyptus camaldulensis* (1.23 in leaves, 1.12% in stem and1.08% in roots) and at last *Taxodium distichum* which recorded the lowest values.

However, the choice of tree species based on growth and absorption of elements is important for the purification of treated wastewater by the tree plantations [30]. Quantity of nutrients absorbed by plants depends on its quantity in the wastewater and plant species [31]. Concerning the effects of waste water in irrigation on N, P and K concentration . The results showed that, macro elements N, P, K were clearly increased. The obtained results varied according to trees species and organs of each tree. These results were in agreement with those reported by Selahvarzi and Hosseini [32] and El-Nennah *et al*. [33] who found that the use of sewage effluent in irrigation resulted in a remarkable change of organic matter available and total soluble N which might have been added to soil. The results were in harmony with Singh and Bahati [1] who found that concentration of N, P and k were greater in foliage compared to the other plant parts . In the same direction Hassan *et al*. [34] found that irrigation with sewage effluent increased most of the macro elements contents and organic matter in the soil cultivated with some trees e.g *Acacia saligna*, *Tipuana speciosa, Melia azedarach*, *Albizia lebbek* and *Taxiodum distichum..*

Heavy Metals Accumulation: The results in this research showed a variable response according to tree species in absorption and accumulation of these metals, as shown in Tables (7, 8 and 9) as following:

Classifying tree species as first, second, third and fourth for their concentrations of the heavy metals in different organs as shown in Table (7), it can be mentioned that, the *Albizia lebbek* seedlings recorded the highest concentration of Ni and Zn, (0.70 and 29.0ppm) respectively in the leaves while it was the second for Cd, Mn and Pb (0.18, 11.30 and 25.00 ppm) and the third for Fe only (36.00 ppm) and the last for Co and Cr (0.12 and 0.02ppm) respectively

Concerning with *Dalbergia sissoo,* it was the first for the accumulation of Mn and Pb (11.70 and28.50 ppm), the second for Ni and Zn (0.67 and 27.90ppm), the third for Co and Cr (0.21 and 0.03 ppm) and the fourth for Cd, Cu and Fe which recorded (0.15, 3.20 and 32.20 ppm) respectively.

Table 7: Effect of secondary treated wastewater irrigation on the heavy metals (ppm) accumulation in leaves after two years from establishment of *Albizia lebbek*, *Dalbergia sissoo, Eucalyptus camaldulensis and Taxodium distichum* seedlings

	Heavy metals (ppm)								
Tree species	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Albizia lebbek	0.18	0.12	0.02	3.90	36.00	11.30	0.70	25.00	29.00
Dalbergia sissoo	0.15	0.21	0.03	3.20	32.20	11.70	0.67	28.50	27.90
Eucalyptus camaldulensis	0.27	0.48	0.05	4.20	40.20	10.01	0.57	24.0	26.77
Taxodium distichum	0.16	0.22	0.04	4.50	36.42	7.50	0.43	21.11	17.91

Table 8: Effect of secondary treated wastewater irrigation on the heavy metals (ppm) accumulation in stem after two years from establishment of *Albizia lebbek*, *Dalbergia sissoo, Eucalyptus camaldulensis and Taxodium distichum* seedlings

	Heavy metals (ppm)								
Tree species	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Albizia lebbek	0.12	0.85	0.03	1.89	23.00	2.23	1.41	33.95	15.20
Dalbergia sissoo	0.13	0.83	0.03	2.98	24.36	2.21	1.50	32.80	15.15
Eucalyptus camaldulensis	0.08	0.92	0.04	1.32	18.22	2.64	1.80	32.50	13.20
Taxodium distichum	0.11	0.63	0.07	1.11	24.60	2.46	1.30	30.60	13.80

Table 9: Effect of secondary treated wastewater irrigation on the heavy metals(ppm) accumulation in roots after two years from establishment of *Albizia lebbek*, *Dalbergia sissoo, Eucalyptus camaldulensis and Taxodium distichum* seedlings

	Heavy metals (ppm)								
Tree species	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Albizia lebbek	0.44	0.65	0.04	5.22	45.22	13.50	0.47	12.30	18.50
Dalbergia sissoo	0.32	0.54	0.04	5.19	48.70	13.37	0.41	12.60	20.17
Eucalyptus camaldulensis	0.39	0.96	0.06	6.30	65.70	14.75	0.65	13.20	17.20
Taxodium distichum	0.43	0.78	0.04	4.80	48.27	14.30	0.39	13.80	15.22

Regarding *Eucalyptus camaldulensis* it was the first for Cd, Co, Cr and Fe as the concentrations were (0.27, 0.48, 0.05 and 40.20 ppm), while it was the second for Cu only (4.20 ppm) and third for Mn, Ni, Pb and Zn which the values were (10.01, 0.57m 24.00 and 26.77ppm), respectively.

The *Taxodium distichum* leaves was the first only in the accumulation of Cu (4.50ppm), the second for Co, Cr and Fe which recorded (0.22, 0.04 and 36.42ppm), the third for Cd (0.16ppm) and the last for Mn, Ni, Pb and Zn (7.50, 0.43,, 21.11 and 17.91ppm), respectively.

Data in Table (8) showed the accumulation of heavy metals in stem of tested species.

The seedlings of *Albizia lebbek* was the first for Pb and Zn (33.95 and 15.20ppm), the second in Cd, Co, Cr and Cu (0.12, 0.85, 0.03 and1.89 ppm), the third for Fe, Mn and Ni which recorded values of (23.00, 2.23 and1. 41 ppm), respectively.

As for *Dalbergia sissoo* it was the first for Cd and Cu (0.13 and 2.98 ppm), the second for Fe, Ni, Pb and Zn (24.30 1.50, 32.80 and 15.15ppm), the third for Co and Cr(0.83 and 0.03ppm) and the fourth for Mn only (2.21ppm) respectively.

Regarding the seedlings of *Eucalyptus camaldulensis,* it showed the highest accumulation for Co, Mn and Ni concentration (0.92, 2.64 and 1.80 ppm), while it was the second for Cr (0.04 ppm) and the third for Cu and Pb (1.32 and 32.50ppm) and the last for Fe, Cd and Zn(18.22, 0.08 and 13.20ppm), respectively.

Concerning *Taxodium distichum* it was the first for Cr and Fe (0.07 and 24.60 ppm) and the second for Mn (2.46 ppm), while it was the third for Zn and Cd (13.80 and 0.11 ppm) and the last for Co, Cu, Ni and Pb (0.63, 1.11, 1.30 and 30.60ppm) respectively.

Data in Table (9) showed the concentration of heavy metals in the roots, of *Albizia lebbek*, *Dalbergia sissoo, Eucalyptus camaldulensis and Taxodium distichum* seedlings.

Albizia lebbek was the first for Cd accumulation (0.44ppm), the second in Cr, Cu, Ni and Zn where the values were (0.04, 5.22, 0.47 and 18.50ppm), the third for Co and Mn (0.65 and 13.50 ppm) while the fourth for Fe and Pb (45.22 and 12.30 ppm) respectively.

Dalbergia sissoo, it was the first for Zn accumulation (20.17 ppm), the second for Cr and Fe (0.04 and 48.70 ppm) and the third for Cu, Ni and Pb (5.19, 0.41 and 12.60 ppm) and the fourth for Cd, Co and Mn (0.32, 0.54 and 13.37 ppm), respectively.

Eucalyptus camaldulensis roots were the first for accumulation of Co, Cr, Cu, Fe, Mn and Ni (0.96, 0.06, 6.30, 65.70, 14.75 and0.65 ppm) respectively, followed by Pb (13.20ppm), the third for Cd and Zn (0.39 and17.20 ppm), respectively.

Concerning with *Taxodium distichum* it was the first for Pb accumulation (13.80ppm), the second for Cd, Co, Cr and Mn(0.43, 0.78, 0.04 and14.30ppm) respectively, the third for Fe (48.27ppm) and it was the fourth for Cu, Ni and Zn, (4.80, 0.39 and 15.22ppm) respectively.

It is worthy to mention that, chromium concentration in roots of *Albizia lebbek*, *Dalbergia sissoo and Taxodium distichum* was of the same accumulation level (0.04ppm) and this result agreed with Pulford *et al.*[35] who confirmed that Cr was shown to be poorly translocated from root to shoot regardless of the form supplied.

The results showed that the distribution of the heavy metals in the different plant organs had a selective character that decreased in the following order:

As, in *E. camaldulensis*: roots > stems > leaves except Zn, Pb and Ni., in *A. lebbek* and *D. sissoo*: leaves > roots > stems > in most of the tested metals while in *T.distichum,* : stems > roots > leaves > in most of the tested metals.

It is clear from the above mentioned results that, the seedlings of the four tree species differed in their absorption and accumulation of heavy metals in their organs. The accumulation was more pronounced in the roots than stem, while the leaves recorded the lowest level of these metals except for Zn that recorded more accumulation in the leaves of different tree species. On the other hand, Ni and Pb showed the maximum accumulation in stem of all species.

Heavy metal absorption and accumulation were affected by tree species, tree age and its concentrations in the soil [36] .It is worth to mention that, the heavy metals accumulation in the roots of studied seedling was more than that in stems and leaves with few exceptions as Zn which accumulated more in leaves while Ni and Pb showed more accumulation in stem . These results agree with Kirkam [37] who mentioned that, heavy metals taken up by plants grown under wastewater tend to remain in the roots and only a fraction of the heavy elements are translocated to the shoots and leaves. Also, the obtained results agreed with Abd El-Hamid *et al.* [38] and Sami *et al*. [39] working on some woody trees as they found that, the roots accumulated more heavy metals than the stems and the lowest concentration of these metals was recorded in the leaves, they agreed with Liu *et al* . [40] who mentioned that some plants have highly specific metabolism to translocation and store elements in roots where the uptake of elements differ according to trees species. In root cells, most of heavy metals bind to peptide and anionic groups and are stored in the vacuole. This mechanism can prevent heavy metal transfer to other organs and protect plant photosynthesis and metabolism. This matter indicates the vital role of plants roots in heavy metal accumulation.

However, there was no regular trend regarding the individual element in the different species of our study and this agreed with Shikhova [41] and Alexandra *et al.* [42].

As, by comparing the whole contents of heavy metals in all tree species seedlings of the studied plants (in biomass dry weight) as shown in Figures (1-9), it should be pointed out that these contents in seedlings of all tree species were different among each other as following:

- For Cd. *A. lebbek* and *E. camaldulensis* accumulated 7.97mg / seedling D.W. then, *D. sissoo* accumulated 6.0mg/ seedling D.W. while *T. distichum* showed the lowest accumulated level of Cd 1.66mg /seedling D.W.
- For Co. *E. camaldulensis* accumulated 25.86 mg/seedling D.W. then *A .lebbek* 25.25 mg/seedling D.W., *D. sissoo* accumulated 9.73 mg / seedling D.W. and *T. distichum* accumulated 4.32 mg/ seedling D.W.
- For Cr. *E. camaldulensis* accumulated 1.59mg/ seedling D.W., *Albizia lebbek* 1.32 mg/ seedling D.W., *D. sissoo* 1.26 mg/ seedling D.W. and *T. distichum* accumulated 0.39mg/ seedling D.W.
- For Cu. *A. lebbek* accumulated 150.03mg/ seedling D.W., *D. sissoo*143.34mg/ seedling D.W., *E. camaldulensis* 127.43 mg/ seedling D.W. and *T. distichum* accumulated 22.65mg /seedling D.W.
- For Fe. *A. lebbek* accumulated 1445.2 mg/ seedling D.W., *E. camaldulensis* accumulated 1355.25mg/ seedling D.W., *D. sissoo*1335.8mg/ seedling D.W. and *T. distichum* accumulated.258.26 mg /seedling D.W.
- For Mn. *A. lebbek* accumulated 360.82mg/ seedling D.W., *E.camaldulensis* accumulated 270.73 mg/ seedling D.W., *D. sissoo* 153.87 mg /seedling D.W. and *T. distichum* accumulated 54.98 mg / seedling D.W.

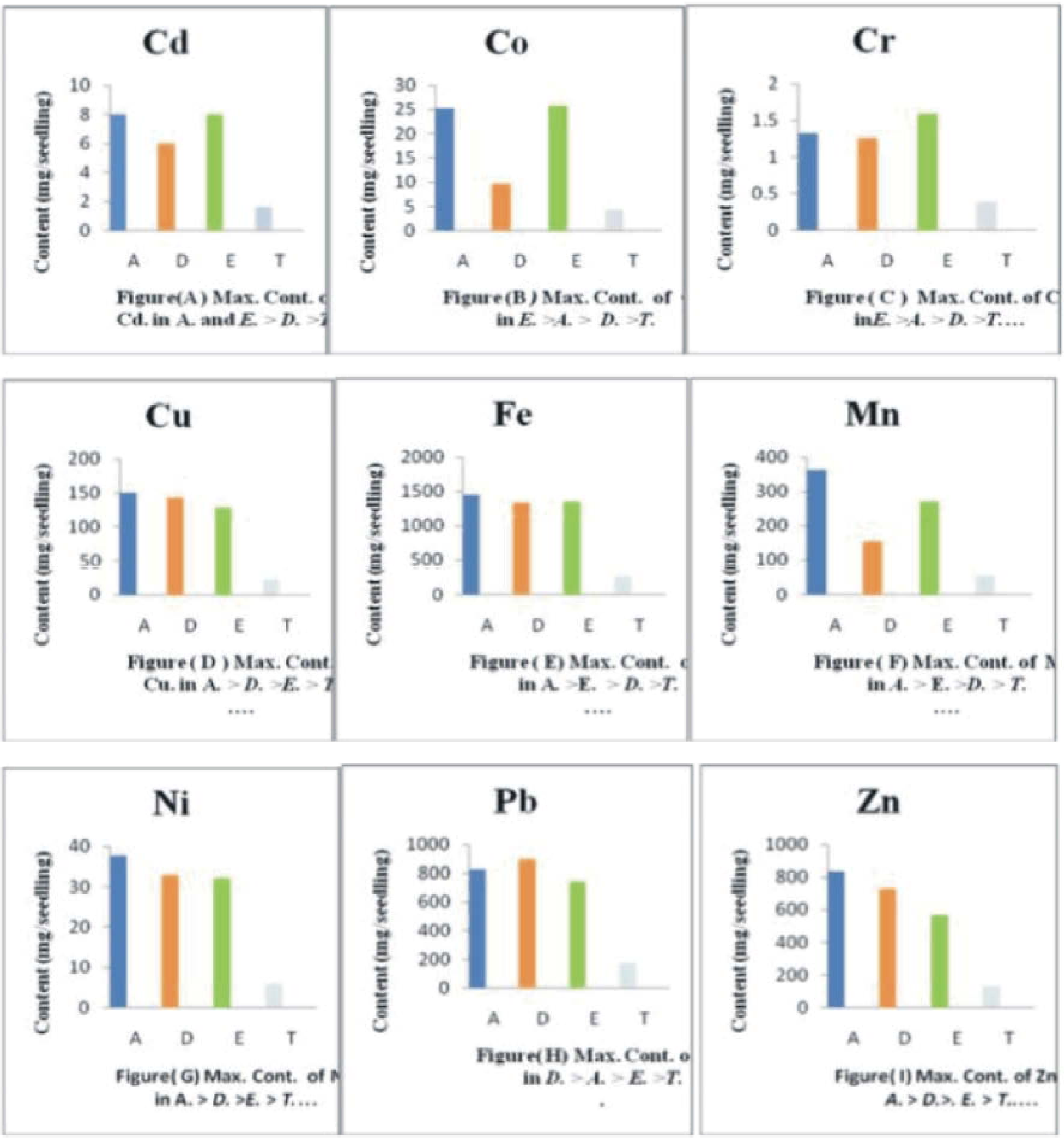

Fig. 1-9: Effect of secondary treated wastewater irrigation on the heavy metals contents (mg/seedling dry weight) in the whole plant after two years from establishment of *A. lebbek*, *D. sissoo, E. camaldulensis and T. distichum* seedlings

- For Ni. *A. lebbek* accumulated 37.76mg/ seedling D.W., *D. sissoo* 32.90 mg/ seedling D.W., *E. camaldulensis* accumulated 32.28mg /seedling D.W. and *T. distichum* accumulated 5.99 mg/ seedling D.W..
- For Pb. *D. sissoo* accumulated 896.9 mg/ seedling D.W., *A. lebbek* accumulated 826.00mg/ D.W. seedling, *E. camaldulensis* 743.10 mg/ seedling D.W. and *T. distichum* accumulated.170.49 mg/ D.W. seedling.
- For Zn. *A. lebbek* accumulated 838.00 mg/ seedling D.W., *D. sissoo*.724.00mg/ seedling D.W., *E. camaldulensis* accumulated 569.5 mg/ seedling D.W. and *T. distichum* accumulated.130.16 mg/ seedling D.W.

The previous results indicated that *Taxodium distichum* recorded the lowest level of all heavy metals accumulation in all species, while *Albizia lebbek* showed the highest accumulative seedling for Cd, Cu, Fe, Mn, Ni and Zn then, *Eucalyptus camaldulensis* for Cd, Co and Cr meanwhile *Dalbergia sissoo* recorded more accumulation for Pb only.

So, in this respect, the studied trees species in this research can be used for the remediation of heavy metals contaminated soils and water and as, the results in this work revealed that *Albizia lebbek* showed more accumulation of heavy metals followed by *Eucalyptus camaldulensis, Dalbergia sissoo* then *Taxodium distichum,* respectively, therefore these tree species can be used for phytoremediation of heavy metals in contaminated soil and water.

CONCLUSION

This study contributes to the evaluation of waste water irrigation of some woody tree species (*Albizia lebbek*, *Dalbergia sissoo, Eucalyptus camaldulensis and Taxodium distichum*), in order to test the possibility of waste water reuse and to investigate a variable tolerance of these woody trees grown under this condition in sandy loam soil. The results showed an increase in all growth characters as well as contents of, total chlorophylls, total sugars and N, P and K%. Also, the results showed that using waste water in irrigation increased all heavy metals accumulation in all studied tree species and this accumulation was more pronounced in the roots than stems and leaves with few exceptions (Zn, Ni and Pb). Also, data showed that *Albizia lebbek* accumulated more heavy metals than the other studied species. Accordingly, *Albizia lebbek* can be considered a very good hyper-accumulator of heavy metals and could be used for cleaning the toxic metals from polluted water and soil followed by *Eucalyptus camaldulensis* and *Dalbergia sissoo*. But field experiments are required for continuous monitoring of heavy metals level in the wastewater irrigated soils. Hence, further detail studies are required to find out its strategies of tolerance mechanism.

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