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Use of Bald Cypress Seedlings for Phytoremediation of Soil Irrigation with Sewage Effluent: Plant Growth and Nutrient Uptake

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This investigation was conducted at a greenhouse in the Nursery of Timber Trees Research Department of Sabahia, Horticultural Research Station in Alexandria Egypt, during 18 months, to study the effects of sewage effluent (primary and secondary) on the growth and chemical composition of *Taxodium distichum* seedlings as well as on soil properties for three periods 6, 12 and 18 months. Primary and secondary treated wastewater were taken from oxidation ponds of New Borg El-Arab city and tap water was used as a control treatment. The primary effluent treatment gave the highest significant values of plant height, stem diameter, leaf area fresh and dry weights of leaves, shoots and roots and shoot/root ratio comparing to the other treatments. Higher significant concentration of N, P, K, Cd, Ni, Pb and Fe in different plant parts resulted from the primary effluent treatment during the three periods of irrigation. Also chemical properties were affected by using different water quality in irrigation under bald cypress plantation. It was found that the concentration of heavy metals in either plant or soil was under the world recommended levels through the irrigation periods. Therefore, it can be used primary sewage effluent in watering of bald cypress seedlings, because it is considered a natural conditioner for the soil through out its organic matter and nutrients. Also, bald cypress could be planted in soil polluted with heavy metals that tested in this study under examined levels without hazardous on human and animals.

Key words: Sewage effluent, Vegetative growth, heavy metals, *Taxodium distichum.*

In many arid and semi-arid countries, water is becoming scarce resource to consider any sources of water, which might be used economically, and effectively to promote further development. At the same time, with population expanding at a high rate, the need for increased agricultural production is apparent.

Many countries have included wastewater reuse as an important dimension of water resources planning. Many communities have practiced excreta reuse and effluent reuse for hundreds of years and it is part of their culture. The quality of river water used in some irrigation projects is such that reuse of human and animal waste is continually taking place, albeit in an uncontrolled fashion. Rapid increases in population and industrial growth have led to more treatments of wastewater in order to reduce pollution and protect receiving waters. It is, then a natural progression to seek direct reuse of this treated

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effluent for lower grade purposes such as irrigation. Irrigation of forest species raised for fuel and timber with wastewater is an approach which helps overcome health hazards associated with sewage farming. Growing the green belts around the cities with forest trees under wastewater irrigation also helps revive the ecological balance and improves environmental quality by self-treatment of wastewater through the application and forest irrigation.

The use of primary and secondary effluent in irrigation can be improved the quality of the soil and plant growth because they are consider a natural conditioners through their nutrient elements and organic mater. However, the direct application of wastewater on agricultural land is limited by the extent of contamination with heavy metals, toxic organic chemicals and pathogens. Also, continuous use of wastewater in irrigation may cause an increase in soluble salts and such an increase may have a deleterious effect on certain crops.

Taxodium distichum Rich. (Bald cypress), is a deciduous or semi deciduous softwood tree belongs to Taxodiaceae family that was widely distributed in the prehistoric forests of Europe and North America. This species is the most distinctive of southern conifers. Bald cypress is a large tree, 100-120 ft high and 3-5 ft in diameter. Because of its great durability (resistance to decay), the wood of bald cypress is often known in the trade as the "wood everlasting". The principal use of bald cypress is in building construction, especially where decay resistance is required. It is frequently used for posts, beams, and other members in warehouses, decks, factories, and bridges (Harlow and Harrar, 1979).

Sebastiani *et al.*, (2004) concluded that leaf area, stem diameter, root and woody cutting biomasses of *Populus deltoides* x maximowiczii-clone Eridano and *P.*X *euramoricana*-clone I-14 which were irrigated by effluent non hazardous levels of heavy metals (Zn, Cu, Cr and Cd) were significantly greater than in the control plants. Also, Zn, Cu and Cr concentrations in plants consistently differed between clones or soil treatments, while Cd levels were always below the detection limits. Both phytoextraction and phytostabilisation strategies were observed in the two clones studied. Another wise, EL-Sayed (2005) found that the growth of trees species (height, stem diameter, fresh and dry weight) of *Acacia saligna*, *Acacia stenophylla*, and *Ceratonia siliqua* was enhanced markedly by using secondary effluent in irrigation compared with tap water.

Data about the use of sewage for irrigation the Egyptian soils are limited, therefore, this work aimed to study the effects of irrigation with sewage effluent on the vegetative growth, and chemical composition of *Taxodium distichum* as well as the soil properties.

MATERIALS AND METHODS

This study was carried out at a greenhouse in the nursery of Timber Trees Research Department of Sabahia, Horticultural Research Station at Alexandria, Egypt. The study lasted for 18 months, to investigate the effects of irrigation with different treatments of sewage effluent on the vegetative growth and chemical composition of *Taxodium distichum* Rich. and soil properties for three periods (6, 12 and 18 months).

Two types of sewage effluent were used for irrigation, primary and secondary treated wastewater that were taken from oxidation ponds of sewage effluent treatment station of New Borg El-Arab City. The sewage effluent that contains a mixture of domestic and industrial sources. Tap water was used as control treatment. The analysis of the used water in irrigation was shown in Table (A). according to the standard methods (APHA, 1995). Trace elements in samples were analyzed using Atomic Absorption Spectrophotometer. Available N was determined by kjeldahl method. Available P was determined by the ascorbic acid molybdenum blue method, (Watanabe and Olsen, 1965). Dissolved Oxygen (DO) was determined by the azide modification of winkler method and Chemical Oxygen Demand (COD) by dichromate oxidation method. Five days Biochemical Oxygen Demand (BOD_5) was determined by amount of oxygen lost after incubation for 5 days in the dark at 20^oC.

One-year-old seedlings of *Taxodium distichum* were used; seedlings averaged 49 cm in height and 5.4 mm in diameter (at 5 cm from the soil surface). The seedlings were planted in earthenware pots (50 cm in height and 50 cm in diameter), filled with 25 Kg of sandy loam soil (one seedling/pot). For three months to adaptation, all seedlings were irrigated with tap water after that started the treatments with sewage effluent. The tree seedlings were irrigated to field capacity to standardize the irrigation rate for the three treatments.

The used soil was sandy loam, which brought from New Borg El-Arab City (60 Km southwest of Alexandria, Egypt). The physical and chemical properties of the soil are showed in Table (B) according to Jackson (1973).

The experimental design Complete randomized design was used for the experimental as described by Snedecor and Cochran (1968). The three treatments replicated three times, each repetition contained four seedlings. The means among of used all treatments were compared by Duncan's Multiple Range Test, according to Snedecor and Cochran (1968).

At the end of each period (6, 12 and 18 months), these seedlings for each treatment were chosen randomly to determine the following data:-

Vegetative growth

Plant height (cm), stem diameter (mm), branches number/plant, leaf area (cm^2)/ leaf, root length (cm), fresh and dry weights (g)/plant for leaves, shoots and roots and shoot/root ratio.

Chemical composition to different parts of plant

N and P% were measured colormetrically determined according to Evenhuis (1976), Murphy and Riley (1962), respectively. K was measured against standard using a Flame Photometer, (Page *et al.*, 1982). Cd, Ni, Pb and Fe (ppm) were determined by Perkin Elmer, 3300 Atomic Absorption Spectrophotometer.

Soil analysis

At the end of each period soil samples were taken from each treatment to determine their chemical properties according to Page *et al.*, (1982).

RESULTS AND DISCUSSION

Effect of sewage effluent treatments on the growth of *Taxodium distichum*

Vegetative growth

Data of the vegetative growth parameters are presented in Table (1). Where the using of different water quality in watering significantly affected the vegetative growth parameters.

Plant height

The primary effluent treatment significantly enhanced the height than the other ones resulted in 84.50, 113.00 and198.00 cm after 6, 12 and 18 months, respectively. Followed by secondary effluent treatment as recorded 75.50, 100.75and161.00 cm after 6, 12 and 18 months from treating, then the irrigation with tap water which gave the significantly shortest plants of 68.50, 90.00 and138.75 cm, consecutively for the three aforementioned periods, respectively.

Reusing the sewage effluent after the treatment for irrigation of the soil has increased its levels of nutrients and organic matter and could be used as a source of plant nutrients or as natural conditioner for the soil properties, (Hopmans *et al.*, 1990), that reflect on the plant composition with an increase of its elements as N, P, K, Ca, Fe, Zn etc., which partake in important components in plant tissues (proteins, fats, carbohydrate, phospholipeds and chlorophylls), consequently better growth.

Stem diameter

In particular, the highest significant stem diameter values were 13.50, 20.10 and 32.43 mm after 6, 12 and 18 months for the treatment of primary effluent. This was followed by secondary effluent that gave 10.65, 16.33and 26.20 mm, then tap water treatment as resulted in 10.65, 16.33 and 26.20 mm after 6, 12 and 18 months, respectively and the differences between them reached the significancy level during the three periods.

The beneficial reuse of treated sewage effluent in irrigation enriched the soil with nutrients and organic matter which decreased soil bulk density (Guo and Sims, 2000) that encouraged the nutrients uptake by plant. Some elements as Cu, Fe and Zn consider as coenzymes as well as the role of elements, especially N, P and K in different physiological processes of metabolites, that enhance the cell division and elongation in the cambium zone.

Branches number

The huge branches number resulted from plants irrigated by primary effluent (13.00, 33.50 and 45.00 /plant after 6, 12 and 18 months, respectively). Whilst the intermediated branches number were 10.00, 25.25 and 34.75 /plant for plants irrigated by secondary effluent, but the least branches number were 7.00, 21.50 and 27.00 for the irrigated plants with tap water after the 6, 12 and 18 months respectively.

Sewage effluent resulted in stimulation of growth in term of branches number by addition of mineral elements particularly Mg and micronutrients, it might have also made some favorable changes in soil plant water matrix. As well as, high leaf number from using primary effluent is obviously due to addition of N and P through municipal effluent addition (Bhati and Singh, 2003 on *Eucalyptus camaldlulensis*).

Leaf area

The irrigated plants with primary effluent had the significant highest values of leaf area of 0.21, 0.25 and0.29 cm^2/leaf after 6, 12 and 18 months, consecutively. Also, the irrigated plants by secondary effluent resulted in a significant increase in leaf area than those irrigated by tap water as gave 0.11, 0.12 and 0.15 cm^2/leaf against 0.05, 0.07 and 0.08 cm^2/leaf for control (tap water) after 6, 12 and 18 months, respectively.

The improvement in the physical and chemical soil properties by addition the organic matter and nutrients through using the sewage effluent in irrigation, it might suggested that the stimulation of elements uptake by plants especially basic nutrients (N and P) as well as Mg and Fe, that reflected on the growth and enhancement the cell elongation and division in leaf tissues, it turn account on leaf area.

Leaves fresh weight

the significantly heaviest fresh leaves resulted from plants watered with primary effluent as recorded 42.04, 99.42 and 233.84 g/plant after 6, 12 and 18 months respectively, from the treating of tree plants. In the second rankled the plants irrigated by the secondary effluent as gave 25.13, 78.35 and 169.01 g/plant thought the three mentioned periods. Finally the irrigated plants by tap water resulted in 11.28,58.61and 88.98 g/plant

Table A. Average composition of water used in irrigation treatments in the experiment.

Parameter	Sewage Effluent		Tap water	Limits of wastewater for agric. reuse (FAO, 1992)
	Primary treatment	Secondary treatment		
pH	6.82	7.56	6.8	6.50 – 8.40
E.C ds/m	1.6	2.96	0.68	3.00 – 7.00
Soluble Cations (meq/L)				
Ca^{++}	2.83	3.34	1.1	—
Mg^{++}	2.21	3.31	1.9	—
K^+	0.23	0.26	0.2	—
Na^+	11.95	16.75	2.6	—
Soluble Anions (meq/L)				
CO_3^{--}	—	—	—	—
HCO_3^-	4.63	5	2	1.50 – 8.50
Cl^-	8.41	9.34	3.8	—
DO (mg/L)	0	2.9	—	—
BOD_5 (mg/L)	220	100	—	40 - 500
COD (mg/L)	402	311	—	80 - 600
TSS (mg/L)	1024	1894	—	—
Available N (ppm)	1.25	1.08	0.26	—
Available P (ppm)	0.38	0.33	0.01	—
Total heavy metals (ppm)				
Cd	0.02	0.01	0.007	0.01
Cu	0.14	0.19	0.009	0.2
Mn	0.06	0.05	0.014	0.2
Ni	0.02	0.01	0.002	0.2
Pb	0.25	0.24	0.02	5
Zn	1.86	1.07	0.09	2
Fe	12.5	8.6	0.26	5

after 6, 12 and 18 months, respectively. The differences among the three treatments reached the significancy level in the three periods when the data were taken.

The superiority of primary effluent treatment in production of leaves fresh weight over the other ones may be due to the increasing in leaf numbers as well as the same reasons aforementioned in leaf numbers. Likewise, Bhati and Singh (2003) reported that marked difference in growth and biomass production under different kinds of effluent application may be due to variations in chemical constituents, particularly metal ions.

Leaves dry weight

Therein, the leaves dry weight of irrigated plant by sewage effluent was significantly greater than the control, though there is a significant difference between both treatments of effluent along the three periods. So, the leaves dry weight took the same trend of leaves fresh weight. The highest dry weight values were 11.10, 27.54 and 75.11 g/plant for primary effluent treatment against 2.76, 17.62 and 36.69 g/plant for the control (tap water) after 6, 12 and 18 months, respectively from the treating of seedlings. Whilst, the secondary effluent treatment gave intermediate values during the three periods of study. The stimulation in leaves dry weight by using the sewage effluent may be attributed to the same explanation in case of leaves fresh weight.

Table B. Physical and chemical analysis of the used soil

Parameter	Mean
Practical size distribution	
Sand %	70
Silt %	20
Clay %	10
Soil texture	Sandy loam
pH	8.31
E.C ds/m	2.42
$CaCO_3$ %	32.04
Organic matter %	0.62
Soluble Cations (meq/L)	
Ca^{++}	5.58
Mg^{++}	6.15
Na^{+}	14.25
K^{+}	0.74
Soluble Anions (meq/L)	
CO_3^{--}	—
HCO^-_3	8.3
Cl^-	9.1
SO_4^{--}	9.42
Available P (ppm)	4.6
Available N (ppm)	7.28
Total heavy metals (ppm)	
Cd	0
Cu	0.77
Mn	1.44
Ni	1.11
Pb	2.13
Zn	0.89
Fe	3.1

Shoots fresh weight

The significantly highest shoots fresh weight was for the irrigated plants with primary effluent were 45.39, 131.51 and 337.67 g/plant after 6, 12 and 18 months from the treating, respectively. This was followed by the watered secondary effluent plants that gave 25.45, 91.95 and 251.61 g/ plant, then control plants as weighed 11.32, 76.49 and 134.62 g/plant, after 6, 12 and 18 months, respectively. Data also cleared that the differences among the three treatments were significant and the shoots fresh weight gradually increased as the irrigation period increased for all treatments.

The marvelous effect of sewage effluent on shoots fresh weight may be through enriched the soil with organic matter and nutrients as a result from applying the treated effluent, that enhanced photosynthesis process by way the basic nutrients, especially N and P and micronutrients as Cu and Zn, consequently more accumulation of metabolic products in shoots (Clemens, 2001 and Clemens *et al.*, 2002).

Shoots dry weight

The highest significant values of dry weight of shoots were 12.97, 48.94 and 149.63 g/ plant after 6, 12 and 18 months, respectively the irrigated plants with primary effluent. Whilst the medium values were 8.79, 31.27 and 99.88 g/plant for irrigated plants by secondary effluent after 6, 12 and 18 months, respectively from the treating. But the tap water resulted in the significantly lightest shoots dry weight of 4.95, 25.09 and 69.13 g/plant after 6, 12 and 18 months, respectively. The differences among all treatments reached the significancy level during the three periods.

Superiority of primary sewage effluent in shoots dry weight than the other treatments may be due to the increase in fresh weight of shoots as well as the same causes mentioned before in case of shoots fresh weight.

Data of the vegetative growth are in accordance to those of Wilson and Dawson (2001) on Salix, Singh and Bhati (2005) on *Dalbergia sissoo*, and Ali *et al.*, 2013 on *Khaya senegalensis* who found that using sewage effluent with different quality enhanced the growth parameters.

Root characters

Roots fresh weight

Data in Table (2) pointed out that the root growth significantly responded to the water quality. The highest weight resulted from the primary effluent, followed by secondary effluent, then tap water with significancy among themselves. Such treatments in the same tidy resulted in 123.72, 137.19 and 483.95 g/plant after 6 months, 80.28, 85.71 and

Table 1. Effect of sewage effluent on vegetative growth parameter of *Taxodium distichum* during 18 months

Treatment Periods	6 months	12 months	18 months	6 months	12 months	18 months
	Plant height (cm)			Stem diameter (mm)		
Tap water	68.50c	90.00c	138.75c	9.05c	13.18c	16.48c
Primary effluent	84.50a	113.00a	198.00a	13.50a	20.10a	32.43a
Secondary effluent	75.50b	100.75b	161.00b	10.65b	16.33b	26.20b
	Branches number / plant			Leaf area/ leaf (cm^2)		
Tap water	7.00c	21.50c	27.00c	0.05c	0.07c	0.08c
Primary effluent	13.00a	33.50a	45.00a	0.21a	0.25a	0.29a
Secondary effluent	10.00b	25.25b	34.75b	0.11b	0.12b	0.15b
	Leaves fresh weight(g/plant)			Leaves dry weight(g/plant)		
Tap water	11.28c	58.61c	88.98c	2.76c	17.62c	36.69c
Primary effluent	42.04a	99.42a	233.84a	11.10a	27.54a	75.11a
Secondary effluent	25.13b	78.35b	169.01b	6.20b	21.96b	57.14b
	Shoots fresh weight(g/plant)			Shoots dry weight(g/plant)		
Tap water	11.32c	76.49c	134.62c	4.95c	25.09c	69.13c
Primary effluent	45.39a	131.51a	337.67a	12.97a	48.94a	149.63a
Secondary effluent	25.45b	91.95b	251.61b	8.79b	31.27b	99.88b

Means followed by a similar letter within a column are not significantly different at the 0.05 level probability by Duncan's Multiple Range Test

Table 2. Effect of sewage effluent on the root characters and shoot/root ratio of *Taxodium distichum* during 18 months

Treatment Periods	6 months	12 months	18 months	6 months	12 months	18 months
	Root fresh weight (g/plant)			Root dry weight (g/plant)		
Tap water	51.34c	53.08c	149.68c	17.18c	20.26c	70.99c
Primary effluent	123.72a	137.19a	483.95a	46.62a	51.20a	190.43a
Secondary effluent	80.28b	85.71b	299.09b	31.76b	38.14b	122.40b
	Root length (cm)			Shoot/root ratio		
Tap water	140.00a	149.75a	177.50a	0.43a	2.10a	1.50a
Primary effluent	105.75ab	115.75b	148.25b	0.51a	1.49b	1.18b
Secondary effluent	80.25b	100.00c	115.00c	0.47a	1.39ab	1.29ab

Means followed by a similar letter within a column are not significantly different at the 0.05 level probability by Duncan's Multiple Range Test

299.09 g/plant after 12 months and 255.12, 198.63 and 142.12 g/plant after 18 months, consecutively. The simulative effect of reuse sewage effluent in irrigation on the roots fresh weight may be referred to amendment the soil characters (physical and chemical) by the addition of organic matter and nutrients, which were increased in roots occupancy zone, led to more nutrients uptake. It may be reflected on the whole growth including roots fresh weight.

Roots dry weight

From data in Table (2) that the highest significant values of roots dry weight resulted from applying the primary effluent as gave 46.62, 1.20 and 190.43 g/plant after 6, 12 and 18 months, consecutively, this was followed by secondary effluent treatment as recorded 31.76, 38.14 and 122.40 g/plant, then the tap water treatment as

Table 3. Effect of sewage effluent on leaves, shoots and roots N, P and K percentage of *Taxodium distichum* during 18 months

Treatment	6 months			12 months			18 Months		
Periods	L	S	R	L	S	R	L	S	R
					N (%)				
Tap water	1.10a	0.83c	0.89c	1.07c	0.88c	0.80c	0.14c	0.29c	0.64c
Primary effluent	1.86a	1.25a	1.75a	2.05a	1.76a	1.57a	1.86a	1.69a	1.52a
Secondary effluent	1.71a	1.02b	1.18b	1.69b	1.22b	1.03b	0.99b	1.14b	1.17b
					P (%)				
Tap water	0.37c	0.34c	0.32b	0.39b	0.22b	0.16b	0.23c	0.19c	0.20b
Primary effluent	0.57a	0.59a	0.44a	0.57a	0.40a	0.28a	0.44a	0.37a	0.38a
Secondary effluent	0.50b	0.48b	0.32b	0.45b	0.33a	0.21b	0.35b	0.28b	0.28ab
					K (%)				
Tap water	0.76b	0.32c	0.41c	0.67a	0.37c	0.32b	1.03c	0.32b	0.26c
Primary effluent	1.44a	0.49a	0.58a	1.10a	0.56a	0.46a	1.39a	0.42a	0.49a
Secondary effluent	0.87b	0.39b	0.47b	0.73a	0.47b	0.42a	1.19b	0.33b	0.40b

Means followed by a similar letter within a column are not significantly different at the 0.05 level probability by Duncan's Multiple Range Test

Table 4. Effect of sewage effluent on leaves, shoots and roots Cd, Ni, Pb and Fe percentage and of *Taxodium distichum* during 18 months

Treatment	6 months			12 months			18 Months		
Periods	L	S	R	L	S	R	L	S	R
					Cd (ppm)				
Tap water	0.30c	0.33c	0.86b	0.38b	0.11c	0.63c	0.05b	0.01c	0.06c
Primary effluent	3.03a	2.30a	2.70a	2.16a	2.56a	2.63a	1.73a	1.26a	1.86a
Secondary effluent	2.13b	1.13b	1.83ab	1.16b	1.83b	1.93b	0.80b	0.63b	0.76b
					Ni (ppm)				
Tap water	11.33c	1.00c	15.33c	12.00b	11.00c	12.00c	12.00c	11.66c	13.33c
Primary effluent	35.33a	32.00a	37.33a	80.00a	131.00a	203.33a	117.33a	126.33a	147.00a
Secondary effluent	26.40b	22.33b	28.00b	76.33a	57.67b	121.67b	75.33b	82.66b	96.33b
					Pb (ppm)				
Tap water	30.00c	31.66c	42.00c	33.33c	35.66c	57.00c	43.33c	31.00c	18.67c
Primary effluent	96.00a	120.66a	131.66a	115.33a	122.00a	175.33a	126.00a	155.66a	183.33a
Secondary effluent	82.33b	90.66b	114.33b	93.00b	83.33b	130.00b	90.66b	83.33b	121.67b
					Fe (ppm)				
Tap water	107.33c	111.33c	105.33c	105.33c	113.67b	190.00b	105.67c	117.00b	160.00c
Primary effluent	311.00a	303.33a	308.33a	338.33a	254.00a	426.67a	316.67a	280.00a	367.33a
Secondary effluent	182.67b	198.91b	254.67b	223.33b	198.33ab	276.67b	236.67b	192.33ab	253.33b

resulted in 17.18, 20.26 and 70.99 g/plant after 6, 12 and 18 months, respectively. Whereas, the differences among the three irrigation treatments were significant through the three period.

The better effect of using the treated sewage effluent on the roots dry weight might be attributed to the same agents has been discussed before.

Root length

Data in Table (2) showed that the used irrigation treatments had no effects on the root length. After 6 months from the treating with irrigation treatments, primary effluent resulted in the longest root of 105.75 cm followed by tap water (140.00cm), then secondary effluent (80.25cm). This result may be due to the accumulation of Na, Ca and Mg as well as some heavy metal as a result of applying sewage effluent, which adversed root elongation at the beginning of the treating. The same trend was obtained from the other two periods were 115.75, 100.00 and 149.75cm after 12 months and 148.25, 115.00 and 177.50 cm after 18 months for the primary effluent, secondary effluent and tap water treatments, respectively. That may be due to organic matter improved the soil permeability as a result from using sewage effluent for long time, therefore, non significant effects on root length from application either tap water or sewage effluent.

Shoot/root ratio

Data in Table (2) demonstrated that there was a slightly effect of the irrigation treatments on the shoot/root ratio, but there is not noticeable significant differences between the effluent treatments along the three periods. But, either two effluent treatments after 6 months or primary effluent after 18 months caused a significant increase in shoot/root ratio comparing to tap water treatment. So, the values of shoot/root ratio were 0.51, 1.49 and 1.18 after 6 months, 0.47, 1.39 and 1.29 after 12 months and 0.43, 2.10 and 1.50 after 18 months for tap water, primary and secondary effluent treatments, respectively. In fact the applying sewage effluent in watering increased shoot/root ratio, particularly after 6 and 18 months from the treating and this due to the increasing in dry biomass of leaves and shoots.

Data of the root characters are in harmony

Table 5. Effect of sewage effluent on the used soil properties during 18 months under *Taxodium distichum* plantation

Parameter		6 months			12 months			18 months		
		Tap water	Primary effluent	Secondary effluent	Tap water	Primary effluent	Secondary effluent	Tap water	Primary effluent	Secondary effluent
pH		8.32	8.59	8.02	8.05	8.02	8.07	8.08	8.29	8.30
E.C ds/m		2.46	2.60	2.89	1.65	2.78	3.00	1.55	2.98	3.19
$CaCO_3$%		29.27	28.48	31.15	27.59	31.15	28.48	32.04	28.48	27.59
O.M%		0.64	0.86	0.82	0.66	1.01	0.98	0.66	1.09	0.99
Ca^{++}	meq/L	7.20	2.50	6.30	3.78	4.10	5.40	3.60	3.60	3.60
Mg^{++}		5.89	4.40	5.28	3.02	3.93	3.95	3.20	2.70	3.00
Na^{+}		12.50	17.50	16.00	8.75	20.00	21.50	9.00	22.00	23.50
K^{+}		0.46	0.82	0.72	0.42	0.74	0.84	0.36	0.58	0.62
CO_3^{--}		—	—	—	—	—	—	—	—	—
HCO_3		3.98	3.65	3.32	2.82	3.15	2.65	3.49	4.15	5.15
Cl^{-}		10.37	13.49	13.23	6.37	16.85	15.94	7.28	13.38	18.20
SO_4^{--}		11.70	9.83	14.15	6.78	8.77	13.10	5.39	12.35	7.97
Available P (ppm)		1.71	7.25	4.34	1.80	7.72	4.74	1.88	8.84	5.92
Available N (ppm)		7.82	15.24	11.20	8.20	17.42	14.56	8.90	54.5	40.92
Cd	DTPA –	—	0.05	0.03	—	0.03	0.02	—	0.03	0.01
Fe	extractable	3.04	3.32	3.18	2.86	3.42	3.36	2.51	3.14	2.95
Ni	heavy	2.10	4.92	4.12	2.00	4.61	3.95	2.00	4.50	3.98
Pb	metals ppm	3.08	3.33	3.00	2.98	3.08	2.95	2.95	2.85	2.74
Cu		0.59	0.74	0.66	0.58	1.07	0.65	0.78	0.84	0.58
Mn		1.44	1.82	1.65	1.32	0.69	0.67	0.70	0.60	0.90
Zn		0.86	0.88	0.76	0.85	0.84	0.68	0.72	0.84	0.64

thase of Sebastiani *et al.,* (2004) on poplar and EL-Sayed (2005) on *Ceratonia silique* and Singh *et al.,* (2013) use different tree seedlings.

Effect of sewage effluent treatments on Chemical composition of *Taxodium distichum*

Nitrogen content

Data in Table (3) revealed that N% in seedlings differed significantly both due to the seedling part and irrigation treatment. Leaves had the highest N% comparing to the shoots and roots after 6 months for the all treatments and the highest N% was recorded from applying primary effluent (1.86 %) in the leaves against 0.83%N in the shoots resulted from tap water. While after 12 months, N% in the plant shoots irrigated with effluent was higher than the other parts, but roots of plants irrigated with tap water contented higher N% than leaves and shoots. The highest N% after 12 months was 1.76% in shoots of plants irrigated by primary effluent. But after 18 months plant leaves had higher N% than the other parts, while the treatment of secondary effluent took the same trend of after 12 months for N% in the different parts, the highest N% (2.05%) in leaves of irrigated plants with primary effluent against 0.88% in shoots of plants as irrigated by tap water. Generally, N% in leaves, shoots and roots of plants irrigated by primary effluent was the highest, followed by that of secondary effluent, then tap water.

Sewage effluent had simulative effect on the N percentage and uptake in different parts of plant and this may due to the increase in available N in the root zone as a result of applying sewage effluent, that reflect on N content in different parts of plant.

Phosphorus content

Data in Table (3) cleared that the used irrigation treatments, differently affected P% in different parts during the different measuring periods. Therein, the application of primary effluent in watering gave the highest P% in the different plant parts during the different periods, followed by secondary effluent, then tap water. Whereas, the highest P% were 0.57% in leaves, 0.40% in shoots and 0.28 in roots of primary effluent plants after 6, 12 and 18 months, respectively. On contrary, the lower P% was 0.32, 0.16 and 0.20 in roots of tap water plant after the such periods, respectively.

In fact that sewage effluent enriched P soil through its organic matter and nutrients, it turn account on P% and uptake in the different parts of plant.

Potassium content

Data in Table (3) showed that primary effluent treatment significantly increased leaves, shoots and roots K percentage comparing to secondary effluent treatment, which failed to appear a significant difference in K% in different plant parts than tap water treatment during the different periods. It was noticed that, K% in the leaves and shoots of plants irrigated with tap water and secondary effluent after 6 months was closely as well as that of primary effluent after 18 months was equal. In general, shoots K% after 6 and 12 months and leaves K% after 18 months was higher than that of the other parts during the same period for all the used treatments. Also, the highest significant K% were 1.10 and 0.56 and 0.46 % in the shoots of irrigated plants with primary effluent against 0.41, 0.32 and 0.26% K in roots of tap water plants, after 6, 12 and 18 months, respectively. This result may be attributed to the increase in available K in the root zone as a result to applying the sewage effluent in the plant irrigation.

Cadmium content

Data in Table (4) cleared that both sewage effluent treatments markedly affected Cd content in different parts of bald cypress plant comparing to tap water. Cd content in the leaves of plants irrigated by either tap water or primary effluent was reduced by increasing the irrigation period, but leaves Cd of secondary effluent plants took the adverse trend. Cd content of the shoots of all irrigation treatments was increased to 12 months then decreased again after 18 months. Roots Cd content of both primary and secondary effluent took the same trend of the shoots, except the plants irrigated with where tap water, roots Cd was increased as irrigation period increased. In different plant parts during the irrigation periods, the use of primary effluent caused a significant increase in Cd concentrations in comparison to the other treatments in most cases.

Nickel content

Data in Table (4) illustrated that Ni concentration did not depended only on irrigation treatment but also on irrigation period. Thus, considerable differences were found in Ni concentration in various plant parts or the same part under the different irrigation treatments. Under tap water leaves and shoots Ni decreased as irrigation period increased but roots Ni took the opposite trend. Under either primary or secondary effluent leaves and roots Ni increased as irrigation period increased, but shoots Ni increased until 12 months, then decreased after 18 months.

Lead content

Significant differences among the used irrigation were found in lead concentrations of the different plant parts (Table 4), whereas, the primary effluent plants had higher significant Pb content in the leaves, shoots and roots, followed by the secondary effluent plants, then tap water plants. Also, it was noticed that the roots Pb concentration was the higher, followed by leaves Pb, then shoots Pb content under the various irrigation treatments, with some exceptions. The Pb concentrations recorded 31.66, 35.66 and 31.00 ppm in shoots of tap water plants also, were recorded 131.66, 175.33 and 183.33 ppm for the roots of primary effluent plants after 6, 12 and 18 months, respectively.

Increasing Pb content in the plants may be due to it increasing in the occupancy root zone as a result to irrigate the soil with sewage effluent therefore, it did not reach the toxicity level.

Iron content

In particular Fe concentration, it is evident from data in Table (4) that used irrigation treatments significantly affected Fe contents in the different plant parts depending on the irrigation period. Therefore, under either tap water or primary effluent during the various irrigation periods the roots Fe concentration was a higher, followed by leaves Fe, then shoots Fe content, except for shoots Fe content was higher than leaves Fe concentration under primary effluent after 12 months. But under secondary effluent, the roots Fe content was a higher, followed by shoots, then leaves along the periods. The highest significant Fe concentrations in the plant parts resulted from using primary effluent treatment in comparison to the others. The iron concentrations had recorded 111.33, 113.67 and 117.00 ppm in shoots of tap water plants to 105.33, 190.00 and 160.00 ppm in roots of primary effluent plants after 6, 12 and 18 months, consecutively.

The using of sewage effluent in irrigation enriched the soil with iron, that reflected on the Fe content in the plant, which it has important role in metabolic processes.

Data of the chemical composition of different parts of *Taxodium distichum* as a result from using sewage effluent treatment are in accordance to those of EL-Sayed (2005) showed that irrigation with secondary effluent led to an increase in concentrations of nitrogen, phosphorus, potassium, calcium, magnesium and sodium in leaves, stem and roots of tree species (*Acacia saligna*, *Acacia stenophylla*, and *Ceratonia siliqua*) compared with using tap water. Also, he found that Fe, Zn, Mn, and Cu increased in leaves, stem and roots of tree species by using secondary effluent in irrigation compared with tap water. Furthermore, heavy metals (Pb, Cd, Cr and Ni) content in tree species, increased in leaves, stem, and roots by using secondary effluent in irrigation compared with tap water. Also, Singh and Bhati (2005) concluded concentrations of N,P, K, Ca, Mg, Cu, Fe, Mn, Zn, were greater in seedlings of *Dalbergia sissoo* were irrigation with municipale effluent than those of the seedlings irrigation by canal water and positively related with the quantity of irrigation. Also, Ali *et al.*, 2011, 2012 and 2013 the concentrations were greatest in foliage compared to the other parts of seedling, with the exception of Cu concentration.

Effect of sewage effluent treatments on soil properties

Data in Table (5) revealed that under *Taxodium distichum* three were changes in soil properties occurred as a result to use the different quality of irrigation water. It was noticed that soil pH values were closely; moreover the irrigated soil by either primary or secondary effluent had pH lower than the virgin soil before planting of 8.02 and 8.30 after 18 months, respectively. Soil E.C differed by differs of treatment and period of irrigation, it ranged from 2.46 ds/m before planting to 1.55, 2.98 and 3.19 ds/m for tap water, primary and secondary effluent, consecutively. Also, $CaCO_3$ slightly affected from using tap water but decreased when sewage effluent was used in irrigation of bald cypress plants. Actually, sewage effluent enriched the soil with organic matter, which increased from 0.64% in virgin soil to 1.09 and 0.99% for primary effluent, and secondary one but the increasing from using tap water was negligible. It happened a notable decrease in soil Ca and Mg contents from the all treatments and marked increase in soil Na and Cl contents from using sewage effluent treatments as well as SO^{--}_4 content from applying secondary effluent. In fact that either primary or secondary effluent exhibit increased the soil content from the basic nutrients N, P and K, but such elements decreased from using the tap water. N ranged from 7.82 ppm before planting to 8.90, 54.50 and 40.92 ppm, P from 1.71 to 1.88, 8.84 and 5.92 ppm and K from 0.46 meq/L to 0.36, 0.58 and 0.62 meq/L after 18 months for tap water, primary and secondary effluent, respectively. Also, the soil content from the basic nutrients (N, P, K) depended on the water type and irrigation period. Regarding the heavy metals soil contents, Cd ranged from zero to 0,00 0.03 and 0.01 ppm, Cu from 0.59 to 0.78, 0.84 and0.58 ppm, Fe from 3.04 to 2.51, 3.14 and 2.95 ppm, Mn from 1.44 to 0.70, 0.60 and 0.90 ppm, Ni from 2.10 to 2.00, 4.50 and 3.98 ppm, Pb from 3.08 to 2.95, 2.85and 2.74 ppm and Zn from 0.86 to 0.72, 0.84 and 0.64 ppm after 18 months from irrigation by tap water, primary effluent and secondary effluent, respectively. It showed that the heavy metal contents either their increment or decrement strongly related to the irrigation treatment and the period application.

Thus, sewage effluent enriched the soil with important elements as N, P, K, Fe and Zn, as well as organic matter, which are very necessary for plant growth and improved the soil physical and chemical properties under *Taxodium distichum* plantation. Therefore, sewage effluents consider a natural conditioner.

These findings are in accordance with those of EL-Nennah *et al.,* (1982) who mentioned that the use of sewage effluents for irrigation year after year markedly increased available P, total and soluble N, soluble born and total and DTPA-extractable heavy metals. Cromer *et al.,* (1984) and Wu *et al.,* (2013) noticed that soil Na, P, K, pH, N and organic matter increased from using municipal effluent in *Pinus radiata* irrigation.

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