

EFFECT OF USING TREATED SEWAGE WATER ON THE YIELD OF SOME TREE SPECIES COMPARED WITH THOSE IRRIGATED BY FRESH WATER

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ABSTRACT

The main objective of this study was to evaluate the impact of irrigating three types of wood trees (i.e. Cupressus sempervirens, Corymbia citriodora and Khaya senegalensis) by treated wastewater as compared with irrigating by fresh water on their biomass growth rate as well as accumulation of different elements in the soil sites. Two experimental field trials were conducted over two consecutive seasons 2018 and 2019 at the two sites. The first site was in the experimental field at the Serapium Forest Plantation in Ismailia governorate, which was dedicated to the safe disposal of treated sewage water, planted with various wooden trees, while the second farm is located at Groppy Nursery in Giza Governorate- West Bank of the Nile where the fresh water(Nil water) was used for irrigation. The study was conducted on the growth of the wood mass above the soil surface of the three tree species. The results showed highly significant growth differences between both locations. The use of treated sewage led to a superiority in the growth of the living mass for tree species compared to those irrigated with fresh water, as it achieved the stock of the wood mass of trees that irrigated with treated sewage (2.68375, 2.44200 And 1.71693 M3 per/ tree) for Khaya senegalensis, Corymbia citriodora and Cupressus sempervirens trees, respectively. The trees showed that Khaya senegalensis gave the highest

.values among the three types. Regarding the presence of minerals and their accumulation of soil under trees, the Serapium Forest Plantation has achieved the highest values for the accumulation of macro and micro-

nutrients, as well as the highest percentages for the accumulation of minerals at all studied depths compared to soil samples taken from areas irrigation of freshwater trees. Therefore, continuous monitoring for soil, water, and plants analysis is necessary.

Key words: Wastewater, *Corymbia citriodora*, *Cupressus Sempervirens*, *Kaya Senegalensis*

INTRODUCTION

Treated wastewater can be used for irrigation under controlled conditions to minimize hazards from toxic and pathogenic contamination to agricultural products, soil and groundwater (Aiello and Consoli 2007). Egypt offers a great prospect for extensive afforestation due to availability of sufficient wastewater and desert land. The afforestation efforts aimed to plant different species as wood and biofuel resources. Sewage water could be used for the establishment of new plantations in desert lands and showed high potential for afforestation of multipurpose species of economic importance. El Kateb and Mosandl (2012) determined the yield of some tree species of the forest plantation in Egypt, which was high and estimated that the volume achieved in Egypt is approximately attained 4.5 times earlier than in Germany, the leading country in Forestry in Europe. Strategies to mitigate these impacts are included with the recommendations for irrigation described by Evett *et al.* (2011). This issue put an important sub-objective of the afforestation, regardless of tree species used, to utilize the trees for removal and sequestration of excess nutrients and chemicals found in the wastewater to prevents much leaching. The effect of soil media on growth and chemical

composition of tree seedlings has been studied by many workers (Shafiq *et al.*, 1979). However, wastewater may contain a variety of pollutants such as salts, bacteria, viruses. The excessive accumulation of trace elements, such as Cd, Cu, Fe, Mn, Pb, and Zn in soils through irrigation creates problems for agricultural production (Singh *et al.*, 2004) and leads to metal uptake by crops, affecting food quality and safety (khan *et al.*, 2008). In this concern, many studies in the temperate showed that tree species have been used as bio accumulators to clean heavy metal such as Ni, Pb, Zn, Cu, and Cd (Pulford and Watson, 2003 and Li, 2006). On the other hand, soil application of treated wastewater is considered a reliable source of nutrients and organic matter useful for maintaining the fertility and productivity of the soil (Rusan *et al.*, 2007). kaur and Najam, (2016) found that application of domestic water increased the yield of crops compared to irrigation with ground water it's also increased total N, P, K and organic matter. Hassan *et.al.* (2003) found that the sewage effluent showed a positive effluence on the growth of commercially important tree by enriching the soil with important essential nutrients as organic matter and contains high concentrations of plant available nutrients. Gharib (2008) studied the effect of irrigation by two types of water, tap water and wastewater drainage and agricultural resulting in Fayoum Governorate on seedlings of white poplar, black poplar and forati poplar. his results showed an increasing in plant height, stem diameter, number of branches, and length of the root, fresh and dry weight in plants irrigated with wastewater. Mazher (2017) found that the effect of irrigation with two types water (tap and

wastewater) on growth, and chemical composition of some woody tree seedlings, growth parameters increased significantly in all seedlings by using wastewater than tap water. Ghorab *et al.* (2011) mentioned that the primary wastewater irrigation increased biomass, basal area and stem volume of some tree forest species. The superior effect of the treated wastewater, compared to fresh water irrigation, may be attributed to the ability of negatively charged particles of organic matter to attract and hold positively charged cation, which allows high availability of water and nutrients to the roots.

The timber of *C. citriodora* is used for light and heavy construction (i.e., bridge construction, flooring, cladding, tool handles and case manufacturing). The wood of young trees has been successfully used for pulp and paper. In Brazil, large plantations have been established for charcoal production. This species has been planted as an ornamental in parks and in reforestation project. It is a favorite source of nectar and pollen in apiculture and gives a light amber honey (Doran, 1999). *Corymbia. citriodora* grows mainly in warm humid areas and coastal regions with mean maximum temperature of about 30-32°C, mean minimum temperatures of about 9-12°C.

Cupressus. sempervirens is cultivated as an ornamental and timber tree. Its wood is used for furniture, veneer, door frames, and window frames. Medicinal uses have been reported for its fruits which are used as anthelmintic, antipyretic, antirheumatic, antiseptic, aromatherapy, astringent, and vasoconstrictor. An essential oil is distilled from the shoots and it is used in perfumery and soap making. It is also planted as a windbreak in

agricultural areas (Farjon, 2013; PROTA, 2015). *Khaya senegalensis*, the African mahogany is now widely used in United States furniture layer as a substitute for American mahogany. Companies there have been keen to replace increasingly costly and scarce American mahogany with more competitive timbers whilst also reacting to domestic and international pressures associated with use of American mahogany from natural stands (Traffic, 2000).

Khaya senegalensis is also well known for its capacity to produce high value timber. Wood characteristics Timber of *K. senegalensis* is highly valued because of its beautiful figurative grain and its rich reddish mahogany brown colour (TRADA, 2004).

The aim of this study is to investigate the effect of using treated wastewater for irrigating some forest trees compared with those irrigated by fresh water on the biomass growth and wood quality of trees, and on the accumulation of different elements in the soil.

MATERIAL AND METHODS

This study was carried out along two successive seasons of 2018 and 2019 at two locations, the first location at Experimental Field at Serapium Forest plantation. North Eastern Egypt (N 30° 28" 49.14' E 32° 13" 29.86'), where the wastewater is used for irrigation., compared with plantation located in the middle Egypt, at Groppy Nursery, Giza Governorate where the fresh water is used. Soil samples were collected at three depths 0-30, 30-60 and 60-

90 cm to study the effect of using treated sewage water on growth of three woody tree species (i.e. *Corymbia citriodora*, *Cupressus sempervirens* and *Khaya senegalensis*).

1. Soils and irrigation water :Some soil physical and chemical properties of the experimental sites are shown in Table 1. On the other hand, the water analysis for both sites are shown in Table 2.

Table (1): Soil physical and chemical analysis for Serapium Forest Plantation and Groppy Nursery witch irrigated with fresh water

Serapium Forest Plantation										
Soil depth cm	pH	EC Dsm-1	Coarse sand %		Fine sand %	Clay %		Silt %	Texture grade	
0---90	7.8	1.7	63.90		45.40	18.00		18.00	Sandy soil	
Water soluble cation (m mole l-1)				Water soluble anion (m mole l-1)				Total nutrition		
Ca ⁺⁺	Mg ⁺⁺		Na ⁺	K ⁺	CO ₃ ⁻⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻⁻	N mg/kg	P mg/kg
3.80	1.60		7.7	0.14	n.d.	0.36	11.12	1.76	129.33	12.73
Groppy Nursery										
0---90	7.2	1.2	63.90		45.40	18.00		18.00	Sandy soil	
Water soluble cation (m mole l-1)				Water soluble anion (m mole l-1)				Total nutrition		
Ca ⁺⁺	Mg ⁺⁺		Na ⁺	K ⁺	CO ₃ ⁻⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻⁻	N mg/kg	P mg/kg
0.80	1.60		0.4	0.2	n.d.	0.20	0.60	0.90	60.00	13.60

Table(2): Chemical analysis of the treated wastewater used for irrigation plantation in Serapium forest plantation and Groppy Nursery Witch irrigated with fresh water

Serapium forest plantation											
TSS mg l- 1	pH	TDS mg l- 1	BOD mg l -1	NH 4-N mg l -1	Total P mg l-1	EC dsm- 1	Pb ppm	Ni ppm	Cd ppm	Cr ppm	K+ ppm
8.6	7.68	620	48.3	23.6	2.89	1.63	1.03	0.05	0.07	0.09	0.46
Groppy Nursery											
n.d.	7.60	275.0	n.d.	n.d.	0.19	0.43	0.10	0.01	n.d.	n.d.	0.39

n.d. = not detected

2. Water analysis: At sampling date, three samples of wastewater were collected and transported to the laboratory in refrigerated bags. They were then kept in a refrigerator, and examined within 24 h of collection. Total suspended solids (TSS), pH, electrical conductivity (EC), total dissolved salts (TDS), biological oxygen demand (BOD), ammonium nitrogen (NH₄-N), phosphorous (P), and heavy metals (Pb, Ni, Cd and Cr) were analyzed according to the standard methods of APHA-AWWA (2005). The data were evaluated according to the Egyptian Code 501/ 2015 for the use of treated sewage in agriculture, Table (3) which clarifies the standard limits of chemical elements in treated sewage, which are reused for food and non-food irrigation purposes, and also according to those recommended by FAO (1992) as indicated in Table (4).

Table (3): The standard limits of chemical elements in treated sewage, which is reused for irrigation according to the(Egyptian Code 501/ 2015).

Element	Long term use Max. conc. (mg/ l)	Short term use Max. conc. (mg/ l)
Aluminum (Al)	5.00	20.00
Arsenic (As)	0.10	2.00
Beryllium (Be)	0.10	0.50
Copper (Cu)	0.20	5.00
Fluoride (F)	1.50	15.00
Iron (Fe)	5.00	20.00
Lithium (Li)	2.50	2.50
Manganese (Mn)	0.20	10.00
Nickel (Ni)	0.20	2.00
Lead (Pb)	5.00	10.00
Selenium (Se)	0.02	0.02
Cadmium (Cd)	0.01	0.05
Zinc (Zn)	5.00	10.00
Chromium (Cr)	0.10	1.00

Table (4): Analysis of primary treated wastewater used for irrigation of non-edible plants as recommended by FAO (1992).

Parameter	pH	Ec (dsm-1)	SAR	Elements (mgL-1)							
				Fe	Mn	Zn	Cu	Pb	Ni	Cd	Cr
Value	6.5: 6	0.7: 3.0	0.7 : 0.2	5.00	0.20	2.00	0.20	5.00	0.20	0.01	0.10

SAR: sodium absorbed ratio EC: electric conductivity

3. Trees: The forest covers about 450 Feddans and it has been successfully greened with timber trees species. Each species was planted in a plot of about 3.5 Feddans (200*75m²) and the space between trees was 3*3m. Three timber trees species were used in this study i.e., *Corymbia*

citriodora, Cupressus sempervirens and Khaya sengalensis. The timber trees were about 23 years old at the end of this experiment.

- 4. The statistical analysis :** The design was a factorial randomized complete block with five replicates. Factors were (A) three tree species (Corymbia, Cupresses and Khaya), (B) two different locations (Serabium Forest Plantation and Groppy Nursery) and (C) two kinds of water (swage water and fresh water). The forest covers about 450 feddans and it has been successfully greened with many timber tree species. The obtained data were analyzed by the two ways ANOVA split plot design. Then, the means were compared by Duncan's multiple range tests at 0.05 probability using CoStat v. 6.400 software (CoStat, 2005) as described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

The obtained data could be discussed as follows:

- 1. Effect of different irrigation water types on the tree growth parameters:** The studied growth parameters are basal area of the tree above the ground, timber volume and tree storage. Data shown in Table (5) indicated that using treated wastewater gave the highest basal area growth values of trees of Corymbia, Khaya and Cupressus which were 0.03330, 0.04146 and 0.02211m², respectively. While the lowest values were obtained for the trees irrigated by fresh water (0.00070, 0.00090 and 0.00060 m²) in the same order. On the other hand, the tree volume values

of the timber trees irrigated by wastewater were 2.44200, 2.68375 and 1.71693m³, and were higher than those irrigated by fresh water (0.00190, 0.00210 and 0.00170m³ in the same respective order. The average trees storage follow almost similar trends.

The variation in the growth rate of trees irrigated by different water qualities could be attributed mainly to the extended organic matter providing the trees with different nutrients, as shown in Table (5). These results agreed with those obtained by kaur and Najam (2016), Hassan *et.al.* (2003), Mazher (2017) and Ghorab *et.al.* (2011).

Table(5): The growth parameters mean values of trees irrigated by wastewater and fresh water.

Season	Season 2018			Season 2019		
	Tree Basal area m ²	Tree Volume m ³	Average tree storage m ³	Tree Basal area m ²	Tree Volume m ³	Average tree storage m ³
Trees irrigated by wastewater						
Corymbia	0.02564	0.36901	0.00055	0.03330	2.44200	0.00088
Khaya	0.03354	1.78175	0.00080	0.04146	2.68375	0.00082
Cupressus	0.01658	1.49150	0.00011	0.02211	1.71693	0.00014
LSD at 5%	0.00477	0.37230	0.00016	0.00429	0.39270	NS
Trees irrigated by fresh water						
Corymbia	0.000600	0.001600	0.0000400	0.000700	0.001900	0.000040
Khaya	0.000800	0.002000	0.000098	0.000900	0.002100	0.000097
Cupressus	0.000500	0.001500	0.000029	0.000600	0.000170	0.000030
LSD at 5%	0.0188	0.0206	0.018	0.0223	0.0215	0.0206

2. Heavy metal concentrations in the soil profiles under study: Data shown in Table (6) indicate the effect of using treated wastewater on the concentrations of macro and micro nutrients as well as heavy metals in soil profile at different depths (layers).

Table (6): Concentrations of macro and micro nutrients and heavy metals of the investigated soil profiles at the end of experiment

Element ppm	Irrigated soil by fresh water			Irrigated soil by wastewater								
				Cupressus			Crombia			Khaya		
	0-30	30-60	60-100	0-30	30-60	60-100	0-30	30-60	60-100	0-30	30-60	60-100
N	60.0	65.0	80.0	66.0	70.0	133	162	134	145	184	192	253
P	13,2	12.5	13.6	13.9	14.3	16.1	14.5	14.1	15.3	17.5	16.6	16.6
K	56,4	60.3	64.0	72.4	74.4	76.2	79.6	76.2	89.6	91.4	94.6	94.6
Fe)	2.86	2.10	1.62	6.7	9.8	7.6	4.8	3.1	6.7	3.7	8.9	10.4
Cu	1.44	1.11	0.40	1.5	1.1	1.3	2.7	2.7	1.8	2.5	1.9	1.6
Zn	1.20	1.10	0.36	2.2	2.1	2.1	2.1	2.1	1.3	1.9	0.9	2.2
Mn)	1.30	1.40	0.50	0.06	0.05	0.4	0.06	0.05	0.04	0.06	0.02	0.03
Pb)	0.02	0.01	0.03	3.9	3.4	2.7	3.57	3.10	3.5	3.56	2.00	3.20
Co	0.01	0.02	0.02	0.30	0.21	0.14	0.30	0.19	0.17	0.83	0.12	0.11
Ni	0.01	0.01	0.01	0.63	0.59	0.34	0.60	0.32	0.29	0.46	0.55	0.73
Cd)	0.01	0.01	0.01	0.24	0.31	0.27	0.20	0.23	0.20	0.22	0.17	0.15

3) The concentration of elements at different depths of soil profile

A) Macro- elements : Based on data in Table (6), it is clear that the mean values of macro nutrients (NPK) concentration have increased in the deeper soil layers of the profile which irrigated by fresh water. Their values were 80.0, 13.6 and 64.0 ppm for N, P and K, respectively. While there were variations in the concentration of the nutrients under wastewater treatment between the soil layers and the tree species. The highest values of N, P and K were obtained at the deepest layer (i.e. 60 to 100cm) under *cupressus* trees, as well as nitrogen and potassium under the kaya trees also phosphorus and potassium only under the trees of *eucalyptus*. While the highest values for nitrogen were recorded(162 ppm) at 0 to 30cm layer under *Corymbia* trees. The highest phosphorus values in

the surface layer were also recorded(17.5 ppm) at 0 to 30cm under the kaya trees.

B) Micro- elements : The results shown in table (6) indicated that the highest values of iron, copper and zinc were at the uppermost surface layer. They were 2.86, 1.44 and 1.20 ppm, respectively. For areas irrigated with treated wastewater, soil analysis under cypressus trees showed that the concentration of iron is higher(9.8ppm) at the middle layer (30 to 60cm), while copper and zinc were concentrated at the surface layer. Moreover, the highest values of copper and zinc were concentrated at the uppermost layer and recorded 2.7ppm and 2.2 ppm, respectively. Iron was the highest at the middle layer as it reached 9.8 ppm. As for the Kaya trees, both iron and zinc showed the highest rates at the deep layer they reached 10.4 and 2.2 ppm, respectively. While copper element was concentrated at the surface layer as it gave 2.5 ppm. As for Mn, it was concentrated at the surface layer as it gave 0.06 ppm. It is clear that trees have evolved highly specific mechanisms to translocate and store micronutrients. Thus, micronutrients uptake mechanisms are of great interest to phytoremediation.

C) Heavy metals: An overview of the results of the concentration of heavy metals in the soil irrigated with fresh water as described in Table (6) indicated that the highest concentration of Pb, Co, Ni and Cd, were located at the deep layer. Their concentrations were 0.03 and 0.02 ppm for items Pb and Co, respectively. For other heavy metals i.e. Ni and Cd they were

similar at all layers (0.01 ppm). On the hand, under wastewater treatment, the concentration of lead and cobalt were in the surface layer of the soil for all tree species as shown in table (6). The concentration of lead reached 3.9 3.57 and 3.56 ppm, for Cupressus, Corymbia and Khaya trees. However, almost no differences were found between soil layers under all studied trees regarding the concentrations of lead or nickel.

The obtained results are in agreement with the results obtained by El Gendi *et al.* (1999), Hassan *et al.* (2003), Mireles *et al.* (2004), Assarch *et al.* (2008) and Ataabadi *et al.* (2010).

CONCLUSION

Egypt, suffers from water scarcity which has become severe in recent years. At present, through the National Program for the Safe Use of Treated Waste Water for Afforestation, substantial volumes of treated effluent generated from sewage treatment plants in cities and villages are used in forest plantations in the desert and bordering areas. Hence, Egypt offers a great prospect for extensive afforestation due to availability of sufficient wastewater and desert land. Soil application of treated wastewater also constitutes a reliable source of nutrients and organic matter. From this standpoint, the aim of this study was to highlight the extent of benefit from treated wastewater and its effect on the positive growth of woody trees. As such, the study highlights on sewage water could be used for the establishment of new plantations in desert lands and showed high potential

for afforestation of multipurpose species of economic importance. The most efficient strategy, however, is to routinely test the concentration of potential contaminants in the wastewater and tree leaves to assess whether some type of leaf collection or reduction of irrigation volume is necessary.

RECOMMENDATION

Utilizing treated wastewater by planting wood trees in Egyptian deserts to take advantage of their wood value and reduce the import gap of timber, as well as contribute to improving the global climate by reducing the proportions of carbon dioxide in the atmosphere, and safe disposal of treated sewage water.

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تأثير استخدام مياه الصرف الصحي المعالجة على إنتاجية بعض أنواع

الأشجار مقارنة مع تلك المروية بالمياه العذبة

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المستخلص

تهدف الدراسة الى تقييم تأثير رى الاشجار الخشبية باستخدام مياه الصرف الصحى المعالجه مقارنة مع الرى باستخدام الماء العذب على معدل نمو الكتلة الحية وتراكم العناصر المختلفة فى التربة، وقد استخدمت ثلاثة انواع من الاشجار الخشبية لتحقيق تلك الدراسة، وكانت الانواع الشجرية المستخدمة هى: الكافور الليمونى والكايا السنغالى والسرو البلدى.

(*Corymbia citriodora*, *Khaya senegalensis* and *Cupressus sempervirens*)

تمت التجربة فى موقعين: الاول بالمزرعة التجريبية بغابة سرايوم بمحافظة الاسماعيلية والتي خصصت للتخلص الامن من مياه الصرف الصحى المعالجه بزراعتها بالانواع المختلفة من الاشجار الخشبية على مدار موسمين متتاليين ٢٠١٨ و ٢٠١٩، بينما تقع المزرعة التجريبية الثانية فى مشتل جروبى بمحافظة الجيزة والتي تم رى الاشجار فيها باستخدام الماء العذب. الدراسة التى اجريت على نمو الكتلة الخشبية فوق سطح التربة للانواع الشجرية الثلاثة سابقة الذكر اظهرت وجود فروق كبيرة فى حالات النمو لكلا الموقعين، وادى استخدام مياه الصرف الصحى المعالجه الى تفوق نمو الكتلة الحية للانواع الشجرية المستخدمة فى هذه الدراسة وهى اشجار (الكافور الليمونى والكايا السنغالى والسرو البلدى) مقارنة بذات الانواع الشجرية والتي تم ريهها باستخدام الماء العذب، حيث حقق مخزون الكتلة الخشبية للاشجار التى تم ريهها بمياه الصرف الصحى المعالجه (٢,٦٨٣٧٥ و ٢,٤٤٢٠٠ و ١,٧١٦٩٣ متر مكعب خشب) لاشجار الكايا ثم اشجار الكافور تليها اشجار السرو على الترتيب. كما اظهرت الدراسة تفوق اشجار الكايا على النوعين الاخرين محل الدراسة.

اما من حيث وجود المعادن وتراكمها فى التربة تحت الاشجار فقد حقق الرى باستخدام مياه الصرف الصحى المعالجه اعلا القيم لتراكم العناصر الغذائية الكبرى والصغرى فضلا عن المعادن الثقيلة على جميع مستويات الاعماق مقارنة بتلك التى تم ريهها باستخدام الماء العذب. وهذا يتطلب استمرار عملية متابعة تحليل التربة والمياه المستخدمة فى الرى والنباتات المروية بها.

الكلمات الدالة: مياه الصرف الصحى - الكافور الليمونى - السرو - الكايا السنغالى