

Phytoremediation Capability and Growth Parameters of Some Tree Species Irrigated with Treated Sewage Water

A- Vegetative Growth

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ABSTRACT

This research was carried out at Serapium plantation located in northeastern Egypt on March 2019, to study the growth rate of three tree species *Tectona grandis* (Linn.), *Gmelina arborea* (Roxb.) and *Azadirachta indica* (A. Juss.) irrigated with treated sewage water after six years of planting in two sites at Serapium plantation, the first site is virgin soil, planted for first time (site1), "afforestation" and the other one is replanted (site2), "reforestation". Results showed good vegetative growth parameters for trees at (site2). On the other hand, *Gmelina arborea* recorded the maximum tree volume (1.16 m³ / tree) compared with the other studied species. Followed by *Azadirachta indica* (0.74 m³ / tree), then *Tectona grandis* (0.24 m³/tree).

Key words: *Tectona grandis*, *Gmelina arborea*, *Azadirachta indica*, sewage water, vegetative growth and tree volume.

INTRODUCTION

In arid and semiarid regions waste water can be used to irrigate inedible crops that can be cultivated in desert soil and margined urban area (Mohammed and Abdullahi, 2010). Nowadays the need to use treated waste water increased, because of the scarcity of fresh water sources in arid and semiarid areas. Moreover, waste water is considered a source of nutrients, as well as a source of heavy metals.

Egypt is one of the dry areas that suffers from water scarcity, so it is necessary to discover and increase water sources, that included the reuse of treated waste water. The use of treated waste water in agriculture specially in plantation is a common practice in many parts of the world (Kiziloglu *et al.*, 2008 and Mansour *et al.*, 2014). Establishment of trees plantations on treated waste water has many environmental, and economic benefits because of the long life time of trees and its biomass production (Sharma and Ashwath, 2006; Madejón *et al.*, 2006). Since 1995, Egypt has established more than 35 plantations all over the country. Moreover, using waste water in irrigation was performed in the framework of the government's plan because of many benefits such as, get rid of large

amount of wastewater safely, improving properties of low soil and producing non edible plants that is tolerate high concentrations of minerals and heavy metals of wastewater, such as, forest trees (Ronald *et al.*, 2011; Nashwa and Zahran, 2014). (Nashwa *et al.*, 2017). *Tectona grandis* (Teak) and *Gmelina arborea* (Gmelina) are belong to the family Verbenaceae. Both are widely cultivated in the rain forest zone (Keay, 1989). *Gmelina* is considered one of the leading plantation species in the world, native Australia. Though, it growing well on deep, well drained and fertile soils, it also can grow in poor soil. It used for pulp and bioenergy production, (Onyekwelu, 2004). As, Teak wood valuable high market demand. It has been established in plantations all over the world far from it's native range (Perez and Kanninen, 2005). *Tectona grandis* and *Gmelina arborea* produced a high quality wood.

Azadirachta indica or 'Neem' or 'Indian lilac' is belongs to family Meliaceae. It's an evergreen or deciduous tree prevalent to tropical regions. Neem is known to produce leaves, fruits and wood and of a wide range of medicinal uses (Dohroo *et al.*, 2016).

The aim of this study is to investigate the growth parameters of three tree species namely, *Tectona grandis*, *Gmelina arborea* and *Azadirachta indica* in desert irrigated with treated sewage water. Also, to study the effect of using sewage water in irrigation for a long time on growth of these species.

Methodology

Three tree species namely, *Tectona grandis*, *Gmelina arborea* and *Azadirachta indica* were planted since November, 2013 in Serapium plantation at two sites: Site 1: Virgin soil, Site 2: soil was planted before with Agave spp. At both sites, the three species were planted at the same time at (2.5mX 2 m) spacing and irrigated with treated sewage water with drip irrigation system. After six years of planting, growth parameters tree total height, stem diameter at 0% of tree height(d0) diameter at breast height (dbh), diameter at 50% of tree height (d0.5), crown width (CW) and tree main stem volume were measured.

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Location:

This experiment was carried out in 2019 at Serapium plantation that located at northeastern Egypt 30°, 29', 15.55" N, and 32°, 14', 25.43" E , roughly 16 km south Ismailia governorate. Tree species were planted in two sites:

Site1: Located at far south west part of the plantation, (virgin soil) "afforestation".

Site 2: Located at north east of site 1, planted for ten years before by sisal (*Agave sisalana*), then it removed and soil was prepared for planting, "reforestation" (Fig.1).

Sampling:

Samples of water, soil and plant parts were collected in 2019 to study the content of heavy metals and minerals.

Water samples of treated sewage water that used in irrigation at the beginning of the experiment (2013) and in (2019) were collected and analyzed (Table, 1).

Soil samples at three depths (30cm, 60 cm and 90 cm) under each tree were collected before planting and after 6 years of planting for the two sites. Then soil samples were prepared for chemical analysis (Black *et*

al., 1965). Soil chemical analysis before planting for the two sites are presented in Tables (2 and 3).

Field (Forest) Mensuration:

Vegetation parameters: Total height, Stem diameter at 0% of total height (d0), Stem diameter at breast height (135 cm from soil surface) (dbh), Stem diameter at 50% of total height (d0.5) and crown width (C W) were measured.

Tree Volume:

- Main stem volume calculation was done by this equation:

$$V = g \times h \times f$$

Where: V is calculated main stem volume (m³), g is basal area at dbh (m²), h is tree's total height (m) and f is form factor (Philip, 1994).

Where:

Tectona grandis form factor is: 0.51 (Fayiah, *et al.*, 2014).

Gmelina arborea form factor is: 0.44 (Mattia and Dugba, 2015).

Azadirachta indica form factor is: 0.38(Nanang *et al.*, 1997).



Fig. 1. Location of Serapium plantation and experimental sites

Table 1. Water analysis in 2013, 2019 and FAO recommendation values of heavy metals

parameter	pH	EC Dsm ⁻¹	SAR	water analysis in 2013									
				Elements mg L ⁻¹									
				N	P	K	Fe	Zn	Cd	Pb	Ni	Co	Cr
	6.6	1.65	4.87	12.0	10.0	4.9	4.50	1.39	0.004	0.08	0.03	0.01	0.006
	6.4	1.6	4.03	28.08	16.0	20.72	0.16	0.42	--	0.02	---	----	0.002
FAO 1992	6 - 6.5	0.7-3.0	0.2-0.7	1 - 40	5.5	10-40	5.00	2.00	0.01	5.00	0.20	0.05	0.10

Table 2. Analysis of soil before planting (Site1)

Depth(cm)	EC (1:2)	pH 1:2.5	N	P	K	Fe	Zn	Cd	Pb
	dS/m		ppm						
0-30	0.34	7.8	154	4597	550	760	57	0.14	65.8
30-60	0.56	7.8	244	2924	440	833	45.5	0.15	70.2
60-90	0.68	7.8	224	2370	181	704	47.1	-	-

Table 3. Analysis of soil before planting (Site2)

Depth(cm)	EC (1:2)	pH 1:2.5	N	P	K	Fe	Zn	Cd	Pb
	dS/m		ppm						
0-30	0.2	6.8	910	7307	360	767	128	0.2	70
30-60	0.57	7.4	896	2681	150	732	62	0.2	70
60-90	0.2	7.1	986	1502	90	672	66		

Experimental design:

Ten trees from each species were selected randomly for each planted site in CRD design. Means were calculated for each parameter, and tested based on Least Significant Differences (LSD) at significant level of $P < 0.05$ using one-way analysis of variance (ANOVA), to compare the growth parameters for both sites and for each tree species (Snedecor and Cochran, 1968).

RERSULTS AND DISCUSSION

1- Vegetative parameters:

It is evident through, statistical analysis data, that there were differences among trees growth parameters in both two sites. Generally, all vegetation parameters of the three tree species revealed that site2 gave the highest values, according to, Table (4) as well be explained later, here.

1-1 Total height:

Statistical analysis of total height for the three tree species after six years of planting in the two sites were varied among studied species. Generally, all the three species showed increase in their total height in site2, whilst, total height means were significantly varied. *Azadirachta indica* showed highly significant differences between the two sites (6.4 and 5.36 m), then, *Gmelina arborea* had a significant differences (6.66, 5.72 m) for site2 and site1, respectively. *Tectona grandis* gave non significant differences between means displayed the lowest height (4.19 and 3.83 m) for site2 and site1, respectively as presented in Table (4).

1-2 Stem diameter at 0% of total height (d0):

According to statistical analysis of Stem diameter at 0% of total height (d0), means of all the three species showed non significant differences between the two sites. However, the means of site2 was higher than site1 for *Gmelina arborea*, *Tectona grandis* and *Azadirachta indica*, 0.53, 0.46; 0.38, 0.34 and 0.62, 0.55m, respectively, as set out in Table (4).

1-3 Stem diameter at breast height (dbh):

Overviewing the statistical analysis of (dbh) means presented in (Table 4), *Azadirachta indica* showed a highly significant differences between Site2 (0.36 m)

and site1 (0.27 m) then, *Gmelina arborea* with significant difference between the two sites (0.39, 0.32 m), respectively. At the same time, *Tectona grandis* showed no significant differences between means of site2 (0.19 m) and site1 (0.16 m).

1-4 Stem diameter at 50% of total height (d0.5):

Allusion to statistical analysis data (Table 4) means of stem diameter at 50% of total height (d0.5) showed the same orientation of dbh data. Where, *Azadirachta indica* means of site2 (0.25 m) and site1 (0.18 m) are highly significant different. On the other hand, the differences between d0.5 means of *Gmelina arborea* site2 (0.28 m) and site1 (0.21 m), were significant only. On the contrary, the differences between d0.5 means of *Tectona grandis* in the two sites (0.13, 0.10 m), respectively were not significant.

1-5 Crown Width (CW)

Statistical analysis data of crown width has revealed significant differences between site2 and site1 for *Gmelina arborea* (4.61 and 3.82 m, respectively) and *Tectona grandis* (3.6 and 2.91 m, respectively). Comparing with means of *Azadirachta indica* (5.58 and 4.9 m), according to (Table 4).

1-6 Tree Volume:

Means of tree main stem volume of studied species were statistically analyzed to express the significantly between volume means among species and between sites. Regarding to Table (4), there were significant differences between volume of trees planted in site2 and site1 for *Gmelina arborea* (1.47 and 0.85 m³, respectively), highly significant for *Azadirachta indica* (0.99 and 0.49 m³, respectively). At the same time *Tectona grandis* showed no significant differences between tree main stem volume in the two sites (0.28m³, 0.20m³). Moreover, the Statistical analysis of the three species volume showed a highly significant differences as presented in Fig (2), where, *Gmelina arborea* recorded the highest volume, followed by *Azadirachta indica* then *Tectona grandis* (1.16m³, 0.74m³ and 0.22m³, respectively) as an average for the two sites.

Table 4. Significant differences of vegetative growth parameters and tree volume means for the three species in the two sites

Tree species	Height (m)		d0 (m)		dbh (m)		d 0.5 (m)		crown width (m)		Tree volume (m ³)	
	Site1	Site2	Site1	Site2	Site1	Site2	Site1	Site2	Site1	Site2	Site1	Site2
<i>Gmelina arborea</i>	5.72 *	6.66 *	0.46 ns	0.53 ns	0.32 *	0.39 *	0.21 *	0.28 *	3.82 *	4.61 *	0.85*	1.47*
LSD 0.05	0.93		0.104		0.06		0.06		0.58		0.46	
<i>Tectona grandis</i>	3.83 ns	4.19 ns	0.34 ns	0.38 ns	0.16 ns	0.19 ns	0.10 ns	0.13 ns	2.91 *	3.61 *	0.20 ns	0.28 ns
LSD 0.05	0.81		0.07		0.05		0.04		0.53		0.19	
<i>Azadirachta indica</i>	5.36 **	6.4 **	0.55 ns	0.62 ns	0.27 **	0.36 **	0.18 **	0.25 **	4.9 ns	5.58 ns	0.49 **	0.99**
LSD 0.05	0.59		0.17		0.06		0.04		1.24		0.29	

*significant

** highly significant

ns. Non-significant

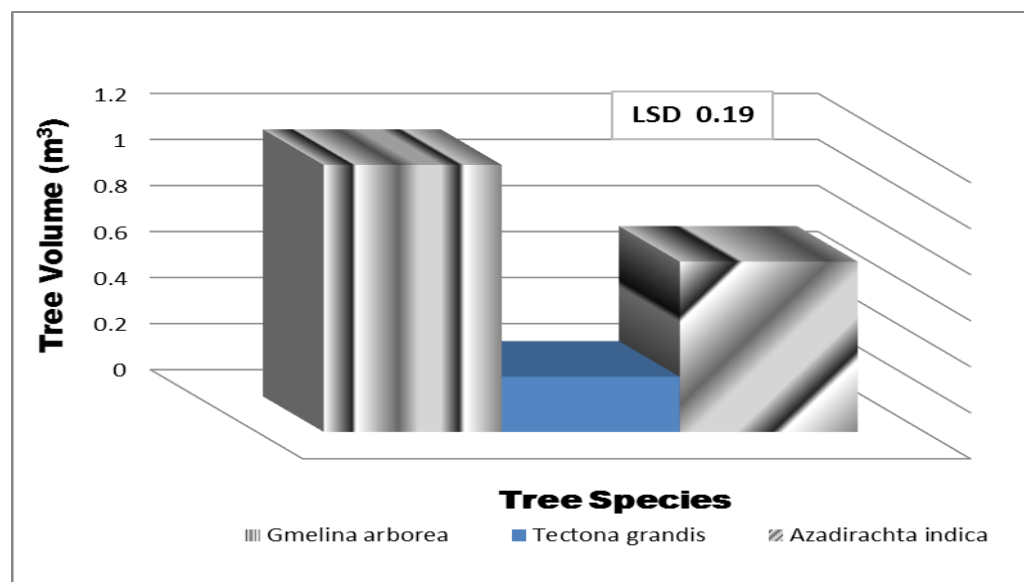


Fig. 2. Tree main stem volume (m³) of the three tree species of the two sites

Overviewing tables (2 and 3) pertaining soil mineral analysis at the beginning of the experiment, we can explain the superiority of all growth parameters in site 2 to the high concentration of nitrogen and phosphorus in site 2 comparing to site 1. Moreover, using sewage water in irrigation for trees in new plantation effluent and stimulate trees vegetative growth, so that, it provides soil with nutrients and organic matter that the plant needs. Moreover, with time it increases nutrients and organic matter concentration and enhance physical properties of the soil like reduction in the soil porosity, and saturated hydraulic conductivity according to (Abedi-Koupai *et al.*, 2006). This result is however, agreed with the findings of many researchers (Abbaas, 2002; Hassan *et al.*, 2002; Bhati and Singh, 2003; EL-Sayed, 2005; Hayssam *et al.*, 2012 and Muamar *et al.*, 2014).

CONCLUSION

Using treated sewage water in irrigation for trees in poor soils has many benefits, one of these benefits is enhancing soil properties, which is reflected in trees growth. Subsequently, site 2 that planted before gave good and high growth parameters than site1 (virgin soil). So, we can conclude from our study that using treated sewage water in irrigation of poor sandy soil for a long time enhance physical and mineral properties of the soil that reflected in the tree growth and volume.

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الملخص العربي

قدرة المعالجة النباتية ومقاييس النمو لبعض الأنواع الشجرية المروية بمياه الصرف الصحي المعالج أ-النمو الخضري.

منال عبد الباقي عبد الرحمن، نشوى حسن محمد

الشجرية في الموقعين تحت الري باستخدام مياه الصرف الصحي المعالج بعد 6 سنوات من الزراعة. وقد أظهرت النتائج تفوق الموقع الثاني (المزروع من قبل) في معدلات النمو المختلفة لجميع الأنواع الشجرية. كما تفوقت المليونيا في الحجم حيث سجلت 1.16 م³ يليها النيم (0.74م³) ثم التيك (0.24م³) للشجرة الواحدة. الكلمات المفتاحية: التيك، المليونيا، النيم مياه الصرف المعالج، النمو الخضري، حجم الشجرة.

أجريت هذه التجربة في غابة سيرابيوم بالإسماعيلية في مارس 2019. حيث تم زراعة 3 أنواع شجرية على مياه الصرف الصحي المعالج وهي التيك *Tectona grandis* والمليونيا *Gmelina arborea* والنيم *Azadirachta indica* وزرعت الثلاث أنواع في موقعين بالمزرعة موقع (1) وهو أرض تزرع لأول مرة وموقع (2) كان مزروع من قبل على مياه الصرف الصحي المعالج وتم إعادة زراعة الموقع. والهدف من البحث هو دراسة مؤشرات النمو الخضري والحجم النامي ومقارنة معدلات النمو المختلفة للثلاثة أنواع