Ability of *Swietenia mahagoni* seedlings to remove of wastewater pollutants and bio-fertilization effect on growth and chemical constituents

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Abstract: Pot experiment was carried out at the Screen of National Research Centre, Cairo, Egypt during the two successive seasons of 2014 and 2015. This study aims to find out the effect of bio-fertilizers (phosphorien, microbien, nitrobien and potassiummage at 10 g/pot) on the growth and chemical constituents of *Swietenia mahagoni* plants on remove of wastewater pollutants. The results showed that application of microbien alone gave the highest values of plant height, number of leaves, stem diameter, fresh and dry weight of stems, while the highest values of root length, fresh and dry weight of leaves and roots were obtained when plants treated with nitrobien compared with other bio-fertilizers and control plants. The effect of interaction between bio-fertilizers and irrigation of wastewater, illustrated that treating plants with microbien and wastewater irrigation significantly increased plant height, number of leaves, stem diameter, fresh and dry weight of leaves and stems, while application of nitrobien with wastewater irrigation significantly increased root length, fresh and dry weight of roots. Concerning the effect of bio-fertilizers on chemical constituents, these results found that application of microbien gave the highest values of Zn, Pb in leaves and stems and carbohydrates percentage in stems. The highest values of Zn, Pb, Cd in the roots, N, P, K in the leaves, stems and roots, chlorophyll a, b, carotenoids in leaves and carbohydrates percentage in leaves and roots were obtained when plants treating with nitrobien compared with other bio-fertilizers and control plants, while application of potassiummage gave the highest values of Cd in leaves and stems. Using microbien with wastewater irrigation led to increase Zn, Pb, Cd in leaves and stems and Pb in roots. Also, N, P, K in leaves, stems and roots and chl. a, b and carotenoids in leaves increased in the application of nitrobien, which gave the highest values of Zn, Cd and carbohydrates percentage in roots. Meanwhile, irrigation with wastewater gave the highest values of all parameters and chemical constituents compared with tap water.

Keywords: *Swietenia mahagoni* plants, wastewater irrigation, bio fertilizers, vegetative growth, chemical constituents

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1 Introduction

The habitat of *Swietenia mahagoni* in Florida and South America is one of the most significant plants of the family, Meliaceae. Various parts of *swietenia mahagoni* have been used as flak medicine for the treatment of hypertension, malaria, cancer, amoebiasis, chest pains, fever, anemia diarrhea, and dysentery, depurative and intestinal parasitism. (Maiti *et al*., 2007).

The wood is therefore the choice for high- quality furniture and cabinet work, joinery, boats and pattern work. It is a large evergreen tree reaches a high of 45 meters, which grown in forests, gardens. It is known as “Almujnb” or “Mojano” and is one of the best species in the furniture industry. In fact, Mahogany is under legal protection in Florida. It is on state’s endangered and threatened list. Mahogany is not suitable for wet areas (Gilman and Waston, 2011).

The effluent water has been a serious factor contributing to soil and water contamination (Rahmani,

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2007). It has been reported that total nitrogen, available phosphorus, organic matter content and selected heavy metals was higher with municipal wastewater as compared to tap water in soil. The use of primary and secondary effluent in irrigation can improve the quality of the soil and plant growth because they are considered as natural conditioners through their nutrient elements and organic matter. However, the direct application of wastewater on agricultural land is limited by the extent of contamination with heavy metals, toxic organic chemical (Singh and Bhati, 2005; Ali *et al*., 2010). Nitrobine is a bio fertilizer (Azotobacter chroococcum and Azospirillum barasilense) as well as other microorganism for mobilizing certain macro-elements for plant absorption. Phosphorien (*Bacillus spp.*) bacteria which lower the pH in rhizospheric soil and produce chelating substances leading to solubiliziation of phosphates. Using of bio fertilizers such as nitrogen and phosphorien enhanced the growth and nutritional status of different plants (Attia *et al.,* 2004). Microbial (Azotobacter sp. A zospirillum sp. and pseudomonas sp. bio fertilizers can induce plant growth parameters, which have been proved by karthikeyan *et al*. (2007) on *Azadirachta indica* and El- Quesni *et al*. (2013) on *Jatropha curcas* L. The applicant of the mixture of *Azotobacter* and *Bacillus* has been confirmed to increase the total carbohydrates in leaves, shoots and roots compared with control plants (Saher, 2008) on Jojopa plants. Application of potassiummage in soil improves soil biota and minimizes the sole use of chemical fertilizers. The bio-fertilizers as potassiummage in agriculture plays a role in improving yield attributing characters and thereby final yield (Mikhail ouskaya and Tcherhysh, 2005) on wheat (Zhang *et al*., 2013).

This study was aimed to find out the ability of mahogany tree to get rid the contaminants, which found in soil contaminated drainage water, and add some vital fertilizers to stimulate the growth.

2 Materials and Methods

This study was carried out at the Screen of National Research Centre, Cairo, Egypt during the two successive seasons 2014 and 2015. This study was aimed to find out the effect of bio-fertilizers on the growth and chemical constituents of *Swietenia mahagoni* plants on remove of wastewater pollutants. The seedlings of *Swietenia mahagoni* were obtained from privet nursery Qualiubiya Governorate. Mahogany seedlings were planted one year of age (30-40cm) in diameter 30 cm pots filled with 6 kg of clay: sand 1:1 (v/v) on the first week of April 2014 and 2015 for the first and second seasons, respectively. Each pot was fertilized twice with 5 g/pot kerstalon by (19:19:19). Irrigation of wastewater after month from planting at the rate of 750 cm^3/pot twice a week with irrigation treatment comparison with tap water. The bio fertilizers were added (a fresh inocula was prepared by bio fertilizer Lab. Ministry of Agriculture, Egypt (Potassiummage, microbien, phosphorien and nitrobien) at the rate of 10 gm/pot after two months from planting and repeat addingafter month from the first one. The Statistical Analyses of the experiment was a completely randomized design included with 10 treatments as follows:

1) Tap water (T.W). 2) T.W + Phosphorien. 3) T.W.+ Microbien. 4) T.W + nitrobien. 5) T.W+ Potassiummage. 6) waste water (W.W). 7) W.W+ phosphorien. 8) W.W+ microbien. 9) W. W+ nitrobien 10) W.W+ potassiummage. Each treatment included three replicates. Through the two successive seasons, a representative plant sample was taken from each treatment and the growth parameters included plant height (cm), number of leaves/plant, root length (cm), stem diameter (cm) and fresh and dry weight (g) of leaves, stems and roots. Chemical analysis was determined nitrogen, phosphorus and potassium according to the methods described by Cottenic *et al*. (1982). Total carbohydrates percentage in leaves, stems and roots were determined according to Dubois *et al.* (1956). Chemical characterization and Potention toxic elements (PTE's) contents of irrigation water was used as Tables (1 & 2). The data were subjected to statistical analysis of variance and the means were compared using the least significant difference (L.S.D.) test at 5% level according to Snedecor and Cochran (1980).

Table 1 Chemical characterization of irrigation water used in the experiments (ppm oven dry basis)*

Type of Water according to Doneen 1954	EC $dS.m^{-1}$	TSS ppm	pH	K	Na	Ca	Mg	SAR	*(0.5 $SO4^{-}$+Cl^{-})
				ppm					
Nile water	0.49	313.6	7.50	0.15	2.35	2.33	1.52	1.60	1.32
Sewaged water irrigation	1.65	1057.8	7.46	0.85	7.77	4.05	3.97	2.77	12.82

Note: * Lepeine canal at Kombera Village.

Table 2 PTE's contents of irrigation water used in the experiments (ppm oven dry basis)*

Type of water	Cd	Cu	Fe	Mn	Pb	Zn	Ni
	mg L^{-1}						
Safe level	0.01	0.20	5.00	0.20	5.00	2.00	0.20
Nile water	-	0.01	0.02	-	-	0.01	-
Sewaged water irrigation	0.05	0.37	2.13	0.26	2.35	2.94	0.17

Note: * Lepeine canal at Kombera Village.

3 Results and Discussion

<u>Vegetative growth:</u>

<u>Effect of bio fertilizers</u>:

When the plants treated with different types of bio fertilizers (phosphorien, microbien, nitrobien and potassiummage). The results showed that in Table 3 all vital fertilizers under study significantly increased for all growth parameters (plant height, number of leaves, root length and stem diameter compared with untreated plants in the two seasons. The highest values of plant height, number of leaves and stem diameter were obtained when the plants treated with microbien, the increments were (46.3, 119.2 and 47.6%) respectively, compared with untreated plants. The use of nitrobien led to increase the root length compared with untreated plants. As shown in Table 4, it is found that the application of microbien biofertilizer treatment significantly increased fresh and dry weight of leaves and roots by 47.6, 130.8, 60.2 and 145.8% respectively compared to the untreated plants in the two seasons. These results are in agreement with those obtained by Mazher (2001) on *Parkinson aculeate* that nitrogen is one of the basic plants nutrients that are built into the body of simple and conjugated proteins and many of organic substances of plants cell. Romero *et al*., (2000) demonstrated that these results might be related to the improvement of physical conditions of soil provided energy for microorganisms activity and increase the availability and uptake of N, P and K, which was reflected on the growth. Moreover, many investigation reported that adding organic manures as fertilizer led to decrease the soil pH, which could increase the solubility and availability of some nutrients to the plants (Kannaiyan, 2002). The treatments of biofertilizer on *Chamaedorea elegans* significantly increased the number

Table 3 Effect of bio-fertilizers, irrigation with wastewater and interaction between them on vegetative growth of *Swietenia mahagoni* plants (average two seasons)

Treaments / Characters	Plant height, cm	No. of Leaves	Root Length	Stem Diameter
Tap Water (T.W.)	82.0	13.0	18.0	1.05
T.W. + Phosphorien	90.0	20.5	20.0	1.20
T.W. + Microbien	120.0	28.5	23.5	1.55
T.W. + Nitrobien	90.5	25.5	34.5	1.35
T.W. + Potassiummage	102.5	27.5	24.5	1.35
Waste Water (W.W.)	118.5	31.0	32.0	1.45
W.W. + Phosphorien	107.0	29.0	32.0	1.40
W.W. + Microbien	155.0	38.0	41.5	2.00
W.W. + Nitrobien	120.5	34.0	44.5	1.75
W.W. + Potassiummage	141.5	34.5	43.0	1.60
L.S.D. at 5%	10.85	2.33	3.02	0.15

Table 4 Effect of bio-fertilizers, irrigation with wastewater and interaction between them on vegetative growth of *Swietenia mahagoni* plants (average two seasons).

Treatments / Characters	F.W. of Leaves	F.W. of Stems	F.W. of Roots	D.W. of Leaves	D.W. of Stems	D.W. of Roots
Tap Water (T.W.)	66.13	40.11	29.41	17.19	11.25	10.53
T.W. + Phosphorien	68.03	57.33	38.88	17.96	12.19	14.19
T.W. + Microbien	97.12	92.57	36.07	26.99	29.90	13.02
T.W. + Nitrobien	97.43	83.11	51.73	27.54	26.60	19.66
T.W. + Potassiummage	78.12	79.92	42.99	21.01	17.66	16.04
Waste Water (W.W.)	105.43	99.21	46.77	30.15	32.64	17.63
W.W. + Phosphorien	79.64	81.65	42.15	21.66	25.80	15.60
W.W. + Microbien	141.09	116.95	54.29	39.76	39.76	21.01
W.W. + Nitrobien	120.40	106.37	64.15	35.52	35.95	25.02
W.W. + Potassiummage	106.37	102.83	51.96	31.15	34.14	19.85
L.S.D. at 5%	8.11	7.95	4.23	2.64	2.32	1.69

of leaves as compared with the control (El-Khateeb *et al*., 2010). Sarhaan *et al*., (2015) found that the values of growth characters were increased when plants treated with microbien at 20 mL/pot.

Effect of waste water:

The present data in Tables 3 & 4 showed that the effect of wastewater treatments on the growth characters of *Swietenia mahagoni* plants. It is clear that all growth parameters were significantly increased under the irrigation with waste water treatments compared with tap water.

The increment were 44.5% for plant height, 138.5% for number of leaves, 77.8% for root length, 38.1% for stem diameter, 59.4% for fresh weight of leaves, 147.3% for fresh weight of stem, 59.0% for fresh weight of roots, 75.4% for dry weight of leaves, 167.8% for dry weight of stems and 67.4% for dry weight of roots, respectively compared with tap water. These results are in agreement with Kayad *et al*. (2005) and Farooq *et al*. (2006). Bed babis *et al.* (2010 and Ali *et al*. (2011) found that the plants were taller by irrigation with sewage water compared to tap water.

Guo and Sims (2000) found that the beneficial reuse of wastewater treatments enriched the soil with nutrients and organic matter which decreased soil bulk density. Hamad (2013) found that fresh and dry weight of roots were significantly increased for the plants irrigated by waste water compared with tap water of *Tamarix aphylla* seedlings. On the other hand, the greater growth production may be due to the sufficient availability of water and essential elements by sewage effluent (Bhati and Singh 2003).

Effect of interaction:

Regarding to the interaction between waste water irrigation and different biofertilizer, Tables 3 & 4 showed that the treatment plants with wastewater combined with microbien significantly increased plant height, number of leaves, stem diameter, fresh and dry weight of leaves and stems. The increments were 89%, 192.3%, 90.5%, 113.4%, 191.5%, 131.3% and 226.2%, respectively compared with the control plants. Irrigation with waste water combined with nitrobien significantly gave the highest root length, fresh and dry weight of roots. The increments were 147.2%, 118.1% and 137.6%, respectively, compared with control plants. Shalaby *et al.* (2003) mentioned that the significant increases in vegetative growth parameters as a result of combined application of bio fertilizers with wastewater may be attributed to the occurrance in net assimilation rate. However, bio fertilizers produce adequate amount of IAA and cytokine, which increased the surface area per unit root length (Jagnow *et al.*, 1991).

Chemical constituents:

Effect of bio fertilizers:

The data in Table 5 indicated that application of microbien led to increase Zn and Pb in the leaves and stems compared with other bio fertilizers and control plants.

Table 5 Effect of bio-fertilizers, irrigation with wastewater and interaction between them on Zn, Pb and Cd of *Swietenia mahagoni* plants (average two seasons)

Treatments \ Characters	Leaves			Stems			Roots		
	Zn	Pb	Cd	Zn	Pb	Cd	Zn	Pb	Cd
Tap Water (T.W.)	48	98	21	51.2	84	24	51.2	124	25
T.W. + Phosphorien	52.2	112	24	53	87	26	54	134	30
T.W. + Microbien	57.6	129	30	68	102	30	52.2	129	28
T.W. + Nitrobien	54.4	108	26	60	92	28	68	150	35
T.W. + Potassiummage	54	117	32	55.4	89	37	57.8	140	32
Waste Water (W.W.)	68	125	36	63	97	41	64	148	40
W.W. + Phosphorien	62.6	121	34	58	96	34	60	145	38
W.W. + Microbien	86.1	144	48	79.2	110	50	73	168	43
W.W. + Nitrobien	78.4	132	42	75	105	44	75.6	160	50
W.W. + Potassiummage	72.3	136	36	72.1	107	46	70.4	154	47

The increments of Zn and Pb were (20% and 32% in the leaves) and (33% and 21% in the stems), respectively, compared with the control plants, while the application of potassium on age gave the highest values of Cd in the leaves and stems compared with other bio fertilizers and control plants. Concerning the effects of bio fertilizers on heavy metals in the roots. Data in Table 5 showed that the application of nitrobien increased Zn, Pb and Cd in the roots compared with the other bio fertilizers and control plants. The increments were 33%, 21% and 40%, respectively, compared with the control plants.

Darwish (2002) reported that bio fertilizers contained microorganisms, which might fix atmospheric N_2 in a free living state, e.g. Azotobacter and Azospirillium. These bacteria excrete some growth promoting factors, such as gibberellin, cytokinine, auxins and some vitamins such as pyridoxine, pantothenic acid and thiamine. Regarding the effects of bio fertilizers on macronutrients, data in Table 6 noticed that treated plants with nitrobien gave the highest values of nitrogen, phosphorus and potassium in the leaves, stems and roots compared with other bio fertilizers and control plants. These results concurred with those claimed by El-Fawakhry *et al*. (2004) on three species of *Ficus*, who reported that the presence of biofertilizer gave the highest values of N in the leaves.

Table 6 Effect of bio-fertilizers, irrigation with wastewater and interaction between them on N, P and K % of *Swietenia mahagoni* plants (average two seasons)

Treatments \ Characters	N %			P%			K%		
	Leaves	Stems	Roots	Leaves	Stems	Roots	Leaves	Stems	Roots
Tap Water (T.W.)	1.4	0.9	0.7	0.1	0.17	0.11	1.1	0.69	0.68
T.W. + Phosphorien	1.5	1.1	0.8	0.11	0.2	0.12	1.16	0.79	0.72
T.W. + Microbien	2.1	1	0.8	0.16	0.19	0.13	1.24	0.72	0.75
T.W. + Nitrobien	2.3	1.4	0.9	0.17	0.29	0.15	1.3	0.95	0.83
T.W. + Potassiummage	1.8	1.2	0.9	0.14	0.22	0.14	1.2	0.81	0.79
Waste Water (W.W.)	2.8	1.4	1.1	0.19	0.26	0.19	1.39	0.92	0.9
W.W. + Phosphorien	2.4	1.3	1	0.19	0.25	0.18	1.35	0.83	0.86
W.W. + Microbien	3.8	1.8	1.7	0.26	0.38	0.24	1.59	1.04	1.02
W.W. + Nitrobien	3	1.7	1.3	0.23	0.35	0.21	1.42	0.99	0.92
W.W. + Potassiummage	3.4	1.5	1.4	0.25	0.31	0.22	1.48	0.98	0.98

Nitrobien contains two non-symbiotic nitrogen fixing bacteria, *Azotobacter chroococcum* and *Azospirillium barasilemse* carried on peat moss, vermiculite and plant charcoal (Shalan, *et al*., 2001).

Concerning the effect of bio fertilizers on total carbohydrates and photosynthetic pigments, data presented in Table 7 reveal that biofertilizer application promoted of total carbohydrates in leaves, stems and roots and photosynthetic pigments in leaves compared with other bio fertilizers and control plants. The highest values were found in plants treated with nitrobien except for total carbohydrates in stems which the microbien gave the highest value of carbohydrates compared with other bio fertilizers and control plants. These results may be attributed to the positive effects of bio fertilizers on sugar metabolism and enhancing the plant growth consequently. The increase of leaf chlorophylls content was reported by El-Gamal (1996), who found that mixed bio fertilizers (Azotobacter and Azospirillum significantly increased considerably in mulberry varieties with Azotobcter in oculation. Olive seedlings also showed the same results (Reddy *et al*, 2003; Abou El-Khashab, 2003).

Effect of Waste water:

Data presented in Tables 5, 6 and 7 indicated that the wastewater individually increased all chemical constituents in different plant organs as compared with tap water.

Irrigation with sewage effluent induced the soil properties because it was considered as a rich source of nutrients (Hassen *et al*., 2006; Tabari and Salehi, 2009). Chlorophyll gives an indirect estimation of the nutrient status because most of leaf nitrogen were incorporated in chlorophyll (Moran *et al*., 2000).

Table 7 Effect of bio-fertilizers, irrigation with wastewater and interaction between them on Carbohydrates % and Photosynthetic pigments of *Swietenia mahagoni* plants (average two seasons)

Treatments \ Characters	Carbohydrates %			Photosynthetic pigments		
	Leaves	Stems	Roots	Chl. a	Chl.b	Carotenoids
Tap Water (T.W.)	14.1	12.3	10	1.543	0.369	0.957
T.W. + Phosphorien	16.5	13.1	10.8	1.554	0.424	0.968
T.W. + Microbien	20.6	18	10.5	1.626	0.375	0.971
T.W. + Nitrobien	22	16.9	15.9	1.655	0.793	0.975
T.W. + Potassiummage	17.4	13.4	12.4	1.587	0.474	0.973
Waste Water (W.W.)	25.1	18.6	14.7	1.704	0.536	0.99
W.W. + Phosphorien	19.5	14.9	11.1	1.603	0.522	0.98
W.W. + Microbien	29.3	22.4	17.8	1.718	1.339	1.006
W.W. + Nitrobien	26.9	20.1	18.9	1.708	0.813	0.993
W.W. + Potassiummage	26	19	17.2	1.705	0.799	1.004

Effect of Interaction:

The interaction between bio-fertilizers and wastewater treatments (Tables 5, 6 and 7) on chemical constituents showed that application of microbien combined with wastewater gave the highest values of all chemical constituents in plant organs, i.e. (Zn, Pb, Cd, N, P, K, total carbohydrates in the leaves, stems and roots and photosynthetic pigments in the leaves) except for Zn, Cd, and total carbohydrates in the roots. The highest values were recorded when plants treated with nitrobien combined with wastewater treatment compared with untreated plants and other treatments.

While the lowest values of chemical constituents were obtained when plants treated with phosphorien combined with wastewater treatments. These results may be due to the irrigated plants. Wastewater increased the values of soil N, P and K, (Mohammad and Mazhreh, 2003). Wastewater was considered as a good source of plant nutrient for improving soil fertility and productivity.

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