J. Product. & Dev., 16(3):527 – 545(2011)

SEWAGE SLUDGE APPLICATIONS FOR ENHANCING GROWTH OF SOME *EUCALYPTUS SPECIES* GROWN IN NEW RECLAIMED SANDY SOIL

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ABSTRACT

This study was carried out at the Experimental Farm of El-Kassasin Hort. Research Station, Hort. Research Institute, Agriculture Research Center, Giza, Egypt, during the two successive seasons of 2008/09 and 2009/10 aiming to evaluate the effect of sewage sludge on growth and chemical composition of some Eucalyptus species (E. citriodora, E. gomphocphala and E. camaldulensis) grown under sandy soil conditions. Sewage sludge was mixed with the sandy medium at five levels of 0, 10, 20, 30 and 40 % (w/ w) before plantation.

Obtained results indicated that E. gomphocphala gave significant increments in all growth parameters; i.e., plant height and stem diameter as well as fresh and dry weights of leaves, stem and roots per plant compared to E. camaldulensis and E. citriodora,. In addition, E. camaldulensis recorded the highest percentages of N, P and K in different plant organs.

Seedlings planted in mixture containing 30 % sewage sludge + 70 % sandy soil, generally, had the highest increments in all growth parameters, uptake and total uptake of N, P and K. Also, level 40 % sewage sludge (mixture medium contain 40 % sewage sludge + 60 % sandy soil) resulted high values of N, P and K % in plant organs.

Regarding the interaction treatments, the highest values of the above mentioned growth parameters, uptake, and total uptake of N, P and K in plant organs were recorded in E. gomphocephala planted in mixture medium 30 % sewage sludge + 70 % sandy soil. Also, plantation of E. camaldulensis in mixture medium containing 40 % sewage sludge + 60 % sandy soil recorded high percentages of N, P and K in plant organs in most cases.

Therefore, it could be recommend that planting Eucalyptus plants especially E. gomphocephala in new reclaimed sandy soils amended with sewage sludge at rate of 30 or 40 %. Since, these combined treatments enhanced plant growth and its uptake of the main essential elements (NPK) and permit a good chance to reduce or eliminate the risk of the

environmental pollution resulted from sewage sludge. Also, E. camaldulensis and E. citriodora can be resulted satisfactory growth in sandy soils amended with sewage sludge.

Key words: Sewage sludge, enhancing growth, *eucalyptus species*, New Reclaimed Sandy soil.

INTRODUCTION

Eucalyptus species (Fam: *Myrtaceae*) naturally occur in all Australian mainland status (Hall *et al*., 1970). They have bean widely planted over seas in areas with Mediterranean climate. However, Eucalyptus species are believed to be introduced into Egypt in the 1800's (El-Lakany *et al.*, 1980). They are highly adapted to the local environmental conditions and grow very fast. These species are traditionally planted as windbreak, for shade and to supply wood for lumber, particle board and charcoal production.

In Egypt, huge amount of sewage sludge (also refereed as biosolids) resulted daily. The raped increase of population, urban planning and the industrial developments resulted more accumulation of it. Additionally, it causes a great environmental problem because the derived risk from the presence of pathogens, heavy metals and organic pollutants in sludge (Harrison *et al*., 2006).

The cultivated area in Egypt exist around the Nile valley and the delta (4% of the total Egypt area), the remaining 96% are desert soil (sandy or calcareous). This soil is lacking organic matter and nutrients. The industrial development and the necessity for desert reclamation to increase the agriculture production to feed the growing population have increased the burden on fertilizer and water resources. It is must to reuse non-conventional water resources (urban sewage water) for irrigation and sludge as organic fertilizer after proper treatment. As a consequence, there is an urgent need for conservation and reuse of wastewater. However, the reuse of sewage water and sludge without proper treatment is the main source of environmental pollution. Proper treatments should be applied before the reuse can take place (El-Motaium, 2006)

Use of sewage sludge (biosolid) as a fertilizer or soil conditioner is the best recycling option from agriculture and environmental view point. Sludge has many advantages in improving soil fertility and increasing crop production (Kumazawa, 1997). Sludge provides the soil with organic matter, nutrients and improves the soil water holding capacity and cations exchange capacity. In addition, the sewage sludge application improves the soil structure and fertility (Cuevas *et al*., 2000 and Mata-Gonzalez *et al*., 2002). However, sludge fertilizer frequently used in agriculture in many countries for enhancing plants

growth and reduce the environmental pollution (Spinosa, 2007). Previous researches proved the enhancing effects of sludge fertilizer on plant growth rate (plant height, stem diameter and fresh and dry weights of plant organs) and increased contents of N, P and K in plant tissues (Androde *and* Mattizzo, 2000 on *Eucalyptus grandis*; El-Baha, 2001 on *E. camaldulensis*; Ya *et al.*, 2001 on *Sesbania rostrata* and S. connabina; Wang *et al*., 2004 on *Pinus rasiata* and El-Settawy and El-Harriry, 2009 on *Acacia saligna*, *Casuarina glauca* and *Eucalyptus camaldulensis*). Also, plant organic matter was increased after sewage sludge applications (Wang *et al.*, 2008).

Therefore, this work aimed to evaluate effects of sewage sludge (biosolids) on growth and mineral uptake of some *Eucalyptus species* grown under sandy soil conditions to determine to what extant *E. species* can be utilize from these biosolids in their growth under new reclaimed sandy soils.

MATERIALS AND METHODS

This study was carried out at the Experimental Farm of El-Kassasin Hort. Research Station, Hort. Research Institute, Agriculture Research Center, Giza, Egypt , during the two successive growing seasons of 2008/09 and 2009/10 aiming to study effects of sewage sludge (biosolids) on growth and mineral uptake of some *Eucalyptus species* grown under sandy soil conditions to determine to what extant *E. species* can be utilize from these biosolids in their growth under new reclaimed sandy soils.

The experimental layout was factorial experiment between three *Eucalyptus species* and five sewage sludge levels, so the experiment was implicated fifteen treatments. These treatments were arranged as a split – plot in a randomized complete block design with three replicates, each replicate contained six plants (six polyethylene bags, each contain one plant). *E. species* were randomly assigned in the main plots, while the sewage sludge levels were randomly arranged in the sub- plots.

The three tested *Eucalyptus species* were *E. citriodora* L. (Limon scented spotted gum), *E. gomphocephala* Dehn (Turat) and *E. camaldulensis* Dehn (River-redgum or Murrary red gum). They were purchased from a commercial nursery as a uniform transplants aged one year old on March 1st for the two tested seasons.

Treatment bulks of sewage sludge were supplied by Ismailia Waste Water Station at Sarabium. Chemical and physical properties of the used sewage sludge are shown in Table 1. It was used only once by mixing it with the sandy medium before *Eucalyptus* transplanting. The five tested levels of sewage sludge were 0, 10, 20, 30 or 40 % (W/ W).

On March 1st during the two tested seasons, sewage sludge at the above mentioned levels were mixed with sandy soil (analyzed as: 83.0% sand, 7.9pH, 0.62% organic matter, 123 ppm N, 199 ppm P and 144 ppm K).

Table 1: Chemical and physical analysis of the used dry sewage sludge

Parameters	Value	Total heavy metals (ppm)	
Organic matter	24.55	**Fe**	92.5
Organic carbon	13.25	**Mn**	166
Total nitrogen	2.20	**Zn**	258
C/N ratio	7.20	**Cu**	735
Available phosphorus	1.30	**Cd**	3
Total potassium	0.48	**Ni**	42
pH (1:2.5 sludge : water)	7.9	**Pb**	201
E.C (1:1 sludge : water, ds/ m)	3.6		

Then, the uniform *Eucalyptus* transplants were transplanted in 17 x 25 cm black polyethylene bags (capacity 8 kg sandy soil), one transplant/ bag. After that, bags were set under lathe house conditions for 15 days, then transferred to the open conditions and all normal agriculture practices were done when ever needed until the end of experiment on March 1st 2009 and 2010 for the 1st and 2nd seasons, respectively (one year after planting).

Recorded data:

On March 1st 2009 and 2010 for the 1st and 2nd seasons, respectively at the end of experiment (one year after planting), responses of eucalyptus plant were evaluated as follows:

1. ***Vegetative growth:*** Vegetative growth responses was recorded as plant height (cm), main stem diameter at base of the main stem (mm) and fresh and dry weights of leaves, stems and roots/ plant (g). In addition total plant fresh and dry weights were calculated.

2. ***Chemical determinations:*** Leaf, stem and root samples for chemical analysis were taken. They were dried at 70°C for 72 hours, finely ground and wet digested. Total nitrogen percentage was colorimetrically determined according to A.O.A.C (1980), and phosphorus percentage was determined according to Olsen and Sommers (1982), as well as potassium percentage was determined using flame photometer according to the method of Chapman and Pratt (1961). Then, N, P and K uptake by different plant organs (roots stem and leaves) were calculated (mg/ kg dry weight).

3. ***Translocation factor (TF) of N, P and K within plant organs:*** Translocation factor (TF) as ratio of the above mentioned elements from root to stem (element % in stem tissues/ element % in root tissues) and from root

to leaves (element % in leaves/ element % in root) was calculated according to Ghorab (2005).

Statistical analysis:

Collected data were subjected to statistical analysis according to Steel and Torrie (1980). Mean separation was done using least significant difference (L.S.D) at 5% level.

RESULTS AND DISCUSSION

1. Vegetative growth:

1.1 Plant height and stem diameter

Presented data in Table 2 revealed that *Eucalyptus gomphocephala* recorded the tallest plants (166.73 and 155.33 cm for 1st and 2nd seasons, respectively) and had the highest value of stem diameter (73.70 and 75.23 mm for 1st and 2nd seasons, respectively) compared to other species. This was true during the two tested seasons. The differences among the studied species may be due to the heredity differences which reflected on their vegetative growth.

As for sewage sludge, plantation of eucalyptus seedling in mixture medium containing 30 % sewage sludge plus 70 % sandy soil gave the tallest plant height (195.33 and 176.44 cm) and recorded the maximum stem diameter (83.22 and 79.38 mm) comparing to the other tested mixture media in the two seasons (Table 2).

Regarding the interaction between plant species and sewage sludge levels, data of the same Table 2 showed that the greatest values for both plant height and stem diameter were recorded in *E. gomphocephala* planted in mixture medium containing 30 % sewage sludge + 70 % sandy soil (205.00 and 193.33 cm and 87.33 and 86.50 mm in the 1st and 2nd seasons, respectively) as compared to other interaction treatments.

The enhancing effect of sewage sludge on eucalyptus plant growth may be due to that sewage sludge had abundant from organic matter as well as N, P and K elements (Table 1). However, such results are in agreement with those found by Yost *et al.* (1987) on *Eucalyptus saligna,* Androde and Mattizzo (2000) on *E. Grandis* and El- Baha (2001) on *E. camaldulensis* with respect sewage sludge. They reported that using sewage sludge gave higher values of growth parameters.

2.1. Fresh and dry weights of leaves, stem and roots per plant

Data in Tables 3 clear that there were significant effects among plant species, sewage sludge applications and their interactions on eucalyptus plant growth represented as fresh and dry weights of different plant organs.

Table 2. Effect of plant species, sewage sludge and their interactions on plant height and stem diameter of *Eucalyptus species* during 2008/09 and 2009/10 seasons

Characters / Treatments		Plant height (cm)		Stem diameter (mm)	
		1st Season	2nd Season	1st Season	2nd Season
Effect of Eucalyptus species:					
E. citriodora		127.46	114.63	68.56	60.36
E. gomphocephala		166.73	155.23	73.70	75.23
E. camaldulensis		151.16	144.86	69.83	67.96
LSD at 0.05 level		**6.43**	**5.18**	**1.099**	**0.70**
Effect of sewage sludge levels*:					
0 %		90.27	87.88	55.13	54.61
10 %		123.94	119.55	63.33	62.05
20 %		157.61	149.11	74.69	70.16
30 %		195.33	176.44	83.22	79.38
40%		175.11	158.22	77.11	73.05
LSD at 0.05 level		**5.66**	**3.36**	**2.01**	**1.66**
Effect of interaction between Eucalyptus species and sewage sludge levels:					
E. citriodora	**0 %**	72.50	76.16	52.25	49.66
	10 %	100.00	97.00	62.16	56.00
	20 %	129.50	118.33	73.08	61.66
	30 %	186.00	155.00	80.00	71.66
	40%	149.33	126.66	75.33	62.83
E. gomphocephala	**0 %**	106.00	97.50	57.16	59.00
	10 %	145.00	135.00	66.33	68.33
	20 %	181.00	169.33	77.00	79.66
	30 %	205.00	193.33	87.33	86.50
	40%	196.66	181.00	80.66	82.66
E. camaldulensis	**0 %**	92.33	90.00	56.00	55.16
	10 %	126.83	126.66	61.50	61.83
	20 %	162.33	159.66	74.00	69.16
	30 %	195.00	181.00	82.33	80.00
	40%	179.33	167.00	75.33	73.66
LSD at 0.05 level		**9.80**	**5.69**	**3.50**	**2.86**

* Sewage sludge was applied by mixing it at different tested rates with the sandy planting medium before eucalyptus seedling transplanting.

Eucalyptus gomphocephala recorded the highest values of fresh weight of leaves (360.10 and 361.00 g), stem (987.68 and 986.71 g) and roots (460.23 and 463.03 g) in 1st and 2nd seasons, respectively. Also, the same species recorded the highest values of dry weight of leaves (180.41 and 180.06 g) stem (594.65 and 593.13 g) and roots (232.96 and 239.83 g) in the 1st and 2nd seasons, respectively as compared to other species.

As for sewage sludge, recorded results in Table 3 showed that plantation eucalyptus plant in mixture medium containing 30 % sewage sludge + 70 % sandy soil resulted the highest values of fresh weight and dry weights of leaves, stem and roots/ plant comparing to the other tested levels of sewage sludge during the two seasons.

In regard to the interaction treatments (Table 3), the highest values of fresh weight of leaves (578.33 and 582.33 g), stem (1591.41 and 1558.50 g) and roots (800.00 and 806.50 g) were obtained by planting of *E. gomphocephala* in mixture medium contain sewage sludge at 30 % and sandy soil at 70 %. Also the same interaction treatment gave the highest values of dry weight of leaves (288.00 and 289.50 g), stem (967.08 and 957.24 g) and roots (403.50 and 405.00 g) comparing to the other combination treatments. This was confirmed in the two seasons (Table 2).

Generally, plant growth is defined as an irreversible increase in volume. Growth is usually measured in terms of changes in fresh and dry weights of the living tissues over a particular period of time (Taiz and Zeiger, 2007). However, Androde and Mattizzo (2000) *on E. Grandis*, El- Baha (2001) *on E. camaldulensis*, Abd El-Kader (2006) on pine seedling and Lazdi *et al.* (2007) on willow plant found that using sewage sludge at different levels gave the better biomass. According to Stein (1997), most seedlings species grow faster in soil treated with sewage sludge; and some species respond dramatically, while others show only a slight response. Greater growth responses have been seen when seedlings have planted directly in soil already amended with large amounts of sewage sludge.

2. Chemical Determinations:

1.2. N, P and K percentages in different plant organs

Results presented in Tables (4 & 5) showed significant differences respecting N, P and K %s in plant organs of different *Eucalyptus species* under study in both seasons. *E. camaldulensis* recoded the highest values of N, P and K %s in stem (1.94 and 1.89 % for N, 0.101 and 0.097 % for P, 1.42 and 1.42 % for K in the 1st and 2nd seasons , respectively), leaf (2.69 and 2.58 % for N, 0.114 and 0.117 % for P and 1.81 and 1.87 % for K in the 1st and 2nd seasons, respectively), and root tissues (2.40 and 2.37 % for N, 0.114 and 0.113 % for P, 1.67 and 1.72 % for K in the 1st and 2nd seasons , respectively).

Table 4. Effect of plant species, sewage sludge applications and their interactions on N, P and K percentages in different plant organs of *Eucalyptus species* during 2008/ 09 season

Characters / Treatments		N (%)			P (%)			K (%)		
		Stem	Leaves	Roots	Stem	Leaves	Roots	Stem	Leaves	Roots
Effect of Eucalyptus species:										
E. citriodora		1.38	2.53	2.01	0.089	0.096	0.093	1.29	1.66	1.62
E. gomphocephala		1.78	2.59	2.28	0.096	0.104	0.099	1.31	1.73	1.66
E. camaldulensis		1.94	2.69	2.40	0.101	0.114	0.114	1.42	1.81	1.67
LSD at 0.5 5 level		**0.02**	**0.07**	**0.07**	**0.002**	**0.002**	**0.010**	**0.04**	**0.02**	**NS**
Effect of sewage sludge levels*:										
0 %		1.00	2.06	1.58	0.079	0.090	0.085	1.03	1.25	1.21
10 %		1.51	2.20	1.78	0.087	0.097	0.094	1.14	1.40	1.35
20 %		1.79	2.65	2.20	0.096	0.103	0.099	1.29	1.68	1.57
30 %		2.06	3.05	2.77	0.105	0.115	0.112	1.46	2.10	2.03
40%		2.13	3.06	2.82	0.111	0.120	0.120	1.79	2.23	2.11
LSD at 0.5 level		**0.08**	**0.05**	**0.08**	**0.026**	**0.003**	**0.005**	**0.05**	**0.04**	**0.07**
Effect of interaction between Eucalyptus species and sewage sludge levels:										
E. citriodora	**0 %**	0.77	1.99	1.26	0.068	0.083	0.079	0.94	1.23	1.20
	10 %	0.97	2.13	1.40	0.079	0.086	0.085	1.11	1.32	1.29
	20 %	1.25	2.57	2.03	0.088	0.091	0.086	1.26	1.67	1.60
	30 %	1.87	2.98	2.62	0.103	0.109	0.108	1.41	2.02	1.96
	40%	2.03	3.01	2.73	0.109	0.114	0.110	1.72	2.10	2.08
E. gomphocephala	**0 %**	1.07	2.05	1.72	0.077	0.090	0.079	1.02	1.24	1.19
	10 %	1.72	2.15	1.94	0.085	0.099	0.094	1.11	1.42	1.36
	20 %	1.97	2.64	2.22	0.101	0.103	0.096	1.30	1.67	1.59
	30 %	2.04	3.06	2.75	0.106	0.113	0.110	1.42	2.07	2.08
	40%	2.09	3.05	2.76	0.112	0.116	0.115	1.72	2.24	2.10
E. camaldulensis	**0%**	1.16	2.15	1.77	0.092	0.097	0.097	1.12	1.30	1.23
	10%	1.84	2.34	1.99	0.096	0.106	0.104	1.20	1.47	1.40
	20%	2.16	2.74	2.34	0.100	0.115	0.116	1.32	1.71	1.53
	30%	2.28	3.11	2.93	0.104	0.124	0.119	1.55	2.21	2.06
	40%	2.27	3.13	2.95	0.110	0.129	0.136	1.93	2.36	2.16
LSD at 0.5 level		**0.14**	**0.10**	**0.14**	**0.046**	**0.006**	**0.009**	**NS**	**0.07**	**NS**

* Sewage sludge was applied by mixing it at different tested rates with the sandy planting medium before eucalyptus seedling transplanting.

The differences among *Eucalyptus species* could be attributed to the genetic differences between them.

Also, results of the same Tables 4 and 5 revealed that mixing sewage sludge with the sandy soil resulted significant increases in N, P and K %s in different eucalyptus plant organ tissues as compared to control treatment during the two tested seasons. The highest percentages of these elements were

Table 5. Effect of plant species, sewage sludge applications and their interactions on N, P and K percentages in different plant organs of *Eucalyptus species* during 2009/10 season

Characters / Treatments		N (%)			P (%)			K (%)		
		Stem	**Leaves**	**Roots**	**Stem**	**Leaves**	**Roots**	**Stem**	**Leaves**	**Roots**
Effect of *Eucalyptus species*:										
E. citriodora		1.41	2.52	2.07	0.090	0.099	0.107	1.25	1.64	1.56
E. gomphocephala		1.75	2.53	2.25	0.095	0.104	0.115	1.29	1.75	1.52
E. camaldulensis		1.89	2.58	2.37	0.097	0.117	0.113	1.42	1.87	1.72
LSD at 0.5 5 level		**0.06**	**0.02**	**0.03**	**0.002**	**0.015**	**0.005**	**0.06**	**0.04**	**0.04**
Effect of sewage sludge levels*:										
0 %		1.03	2.07	1.64	0.077	0.090	0.092	1.04	1.23	1.17
10 %		1.47	2.19	1.85	0.084	0.098	0.107	1.14	1.41	1.29
20 %		1.75	2.61	2.17	0.096	0.104	0.113	1.27	1.71	1.55
30 %		2.06	2.90	2.71	0.104	0.117	0.122	1.44	2.16	1.88
40%		2.09	2.96	2.77	0.109	0.123	0.123	1.72	2.25	2.10
LSD at 0.5 level		**0.05**	**0.04**	**0.06**	**0.003**	**0.004**	**0.005**	**0.03**	**0.04**	**0.05**
Effect of interaction between Eucalyptus species and sewage sludge levels:										
E. citriodora	**0 %**	0.87	2.01	1.32	0.072	0.083	0.084	0.99	1.15	1.11
	10%	0.98	2.13	1.51	0.078	0.089	0.099	1.09	1.30	1.25
	20%	1.25	2.55	2.05	0.089	0.092	0.106	1.20	1.66	1.55
	30%	1.93	2.96	2.67	0.101	0.107	0.120	1.38	2.02	1.89
	40%	2.02	2.97	2.81	0.110	0.122	0.123	1.59	2.08	2.00
E. gomphocephala	**0 %**	1.05	2.06	1.77	0.075	0.088	0.096	1.02	1.23	1.16
	10%	1.64	2.15	1.99	0.083	0.100	0.110	1.14	1.43	1.25
	20%	1.93	2.61	2.16	0.099	0.104	0.117	1.29	1.71	1.50
	30%	2.05	2.92	2.66	0.107	0.114	0.126	1.40	2.13	1.67
	40%	2.06	2.95	2.68	0.110	0.115	0.127	1.62	2.24	2.02
E. camaldulensis	**0 %**	1.18	2.14	1.84	0.085	0.100	0.096	1.12	1.31	1.26
	10%	1.81	2.28	2.07	0.090	0.105	0.110	1.19	1.50	1.38
	20%	2.07	2.68	2.31	0.099	0.117	0.117	1.31	1.76	1.60
	30%	2.20	2.84	2.81	0.104	0.128	0.120	1.56	2.32	2.08
	40%	2.20	2.96	2.84	0.107	0.133	0.120	1.94	2.44	2.28
LSD at 0.5 level		**0.10**	**0.07**	**0.10**	**0.005**	**0.006**	**NS**	**0.06**	**0.07**	**0.09**

* Sewage sludge was applied by mixing it at different tested rates with the sandy planting medium before eucalyptus seedling transplanting.

recorded in tissues of plants grown in sandy soil containing 40 % sewage sludge (2.13 and 2.09 % for N, 0.111 and 0.109 % for P and 1.79 and 1.72 % for K in stem; 3.06 and 2.96 % for N, 0.120 and 0.123 % for P and 2.23 and 2.25 % for K in leaves; as well as 2.82 and 2.77 % for N, 0.120 and 0.123 %

for P and 2.11 and 2.10 % for K in roots during 1st and 2nd seasons, respectively).

For the interaction treatments (eucalyptus plant species X sewage sludge levels), it could be observed that *E. camaldulensis* plant grown in mixture medium containing 40 % sewage sludge plus 60 % sandy soil had the highest percentages of N, P and K in stem, leaves and roots compared to the all other interaction treatments. This was confirmed during the two tested seasons (Tables 4 & 5).

2.2. Uptake and total uptake of nitrogen

Data in Table 6 show that there were significant differences among the three tested eucalyptus species for uptake and total uptake of nitrogen in plant organs in the two seasons. *Eucalyptus gomphocephala* had the highest values of N uptake in stem (11.487 and 11.299 g / Kg DW in the 1st and 2nd seasons, respectively) compared to other plant organs. Also, it is recorded the highest mean value of total N uptake per plant (22.225 and 21.886 g/ kg DW in the 1st and 2nd seasons, respectively).

Plantation of eucalyptus in sandy soil containing 30 % sewage sludge resulted the highest values of N uptake in all plant organs (14.511 and 14.218 g/ kg DW in stem, 7.294 and 6.923 g / kg DW in leaves , 7.705 and 7.571 g/ kg DW in roots in the 1st and 2nd seasons, respectively).

Also results of interaction between *Eucalyptus gomphocephala* and plantation in 30 % sewage sludge +70 % sandy soil (Table 6) showed higher values of N uptake in stem, roots and leaves, respectively (19.758 and 19.616 g/ kg DW for stem, 8.812 and 8.453 g/kg DW for leaves, as well as 11.121 and 10.785 g/kg DW in roots in the 1st and 2nd seasons, respectively) and total N uptake in both seasons (39.691and 38.856g/kg DW).

3.2. Uptake and total uptake of phosphorus

Data in Table 7 reveal that there were significant differences among eucalyptus species in most cases. However, *E. gomphocephala* recorded high P uptake in stem (0.605 and 0.597 mg/kg DW) and total P uptake/ plant (1.051 and 1.050 mg/kg DW) for 1st and 2nd seasons, respectively. The variability among the studied species might be due to the heredity differences

Plantation plants in sandy soil containing 30 % sewage sludge recorded the highest values of P uptake in different plant organs and total P uptake for two seasons (0.718 and 0.711 g/ kg DW in stem, 0.277 and 0.282 g / kg DW in leaves and 0.320 and 0.331 g/ kg DW in roots and 1.316 and 1.325 g / kg DW) for total uptake in the 1st and 2nd seasons, respectively (Table 7).

For interaction treatments (Table 7), *E. gomphocephala* planted in mixture of sewage sludge at 30 % + sandy soil at 70 % had the highest values

Table 6. Effect of plant species, sewage sludge applications and their interactions on N uptake by different plant organs and total uptake/ plant (g /kg DW) of *Eucalyptus species* during 2008/09 and 2009/10 seasons

Characters / Treatments		N uptake (g/ kg DW)						Total N uptake (g/ kg DW)	
		Stem		Leaves		Root			
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Effect of Eucalyptus species:									
E. citriodora		2.587	2.575	2.539	2.453	1.165	1.281	6.291	6.311
E. gomphocephala		11.487	11.299	4.965	4.819	5.772	5.767	22.225	21.886
E. camaldulensis		10.685	10.503	4.984	4.700	4.843	4.790	20.513	19.994
LSD at 0.05 level		**0.620**	**0.351**	**0.416**	**0.164**	**0.075**	**0.371**	**0.557**	**0.527**
Effect of sewage sludge levels*:									
0 %		1.725	1.856	1.518	1.497	1.203	1.335	4.447	4.688
10 %		4.777	4.701	2.308	2.254	1.880	2.230	8.966	9.186
20 %		8.197	8.035	4.121	4.024	3.112	3.091	15.431	15.151
30 %		14.511	14.218	7.294	6.923	7.705	7.571	29.510	28.713
40%		12.056	11.819	5.572	5.258	5.734	5.504	23.362	22.581
LSD at 0.05 level		**0.356**	**0.297**	**0.266**	**0.210**	**0.249**	**0.298**	**0.405**	**0.516**
Effect of interaction between Eucalyptus species and sewage sludge levels:									
E. citriodora	**0 %**	0.727	0.832	1.160	1.154	0.449	0.581	2.337	2.568
	10 %	1.263	1.270	1.794	1.737	0.677	0.735	3.735	3.742
	20%	2.353	2.357	2.372	2.206	1.173	1.201	5.900	5.765
	30%	4.421	4.523	4.370	4.306	1.856	2.094	10.647	10.924
	40%	4.170	3.894	2.997	2.864	1.670	1.796	8.838	8.555
E. gomphocephala	**0 %**	2.284	2.275	1.719	1.696	1.624	1.766	5.627	5.738
	10%	6.833	6.595	2.663	2.700	2.870	3.677	12.367	12.973
	20%	11.457	11.151	5.012	4.984	4.586	4.415	21.057	20.550
	30%	19.758	19.616	8.812	8.453	11.121	10.785	39.691	38.856
	40%	17.104	16.861	6.620	6.264	8.661	8.190	32.386	31.315
E. camaldulensis	**0 %**	2.165	2.461	1.674	1.640	1.535	1.656	5.375	5.758
	10%	6.236	6.239	2.467	2.325	2.094	2.278	10.797	10.843
	20%	10.780	10.596	4.979	4.883	3.577	3.656	19.337	19.137
	30%	19.353	18.515	8.699	8.009	10.138	9.835	38.192	36.359
	40%	14.894	14.701	7.099	1.154	6.869	6.525	28.863	27.873
LSD at 0.05 level		**0.615**	**0.518**	**0.460**	**0.364**	**0.432**	**0.516**	**0.700**	**0.894**

* Sewage sludge was applied by mixing it at different tested rates with the sandy planting medium before eucalyptus seedling transplanting.

Table 7. Effect of plant species, sewage sludge applications and their interactions on P uptake by different plant organs and total uptake/ plant (g /kg DW) of *Eucalyptus species* during 2008/09 and 2009/10 seasons

Characters / Treatments		P uptake (g/ kg DW)						Total P uptake (g/ kg DW)	
		Stem		Leaves		Root			
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Effect of *Eucalyptus species*:									
E. citriodora		0.159	0.157	0.095	0.094	0.054	0.059	0.309	0.310
E. gomphocephala		0.605	0.597	0.193	0.194	0.252	0.259	1.051	1.050
E. camaldulensis		0.520	0.515	0.207	0.211	0.220	0.228	0.947	0.955
LSD at 0.05 level		**0.038**	**0.013**	**0.013**	**0.010**	**0.013**	**0.018**	**0.031**	**0.025**
Effect of sewage sludge levels*:									
0 %		0.133	0.135	0.066	0.065	0.066	0.071	0.265	0.272
10 %		0.254	0.248	0.102	0.101	0.099	0.114	0.456	0.464
20 %		0.415	0.414	0.162	0.163	0.146	0.149	0.724	0.727
30 %		0.718	0.711	0.277	0.282	0.320	0.331	1.316	1.325
40%		0.620	0.606	0.218	0.220	0.244	0.245	1.083	1.071
LSD at 0.05 level		**0.020**	**0.019**	**0.009**	**0.010**	**0.010**	**0.016**	**0.019**	**0.026**
Effect of interaction between *Eucalyptus species* and sewage sludge levels:									
E. citriodora	**0 %**	0.063	0.068	0.048	0.047	0.029	0.036	0.141	0.152
	10 %	0.102	0.100	0.072	0.072	0.041	0.043	0.216	0.216
	20 %	0.164	0.168	0.084	0.079	0.052	0.053	0.301	0.301
	30 %	0.242	0.235	0.159	0.156	0.077	0.084	0.479	0.476
	40%	0.224	0.212	0.113	0.117	0.069	0.078	0.407	0.408
E. gomphocephala	**0 %**	0.164	0.162	0.075	0.072	0.084	0.088	0.324	0.322
	10 %	0.336	0.333	0.122	0.125	0.146	0.184	0.605	0.643
	20 %	0.583	0.568	0.194	0.197	0.211	0.211	0.989	0.977
	30 %	1.028	1.027	0.325	0.330	0.456	0.461	1.809	1.818
	40%	0.916	0.894	0.250	0.244	0.362	0.351	1.530	1.490
E. camaldulensis	**0 %**	0.172	0.176	0.075	0.076	0.084	0.089	0.332	0.343
	10 %	0.325	0.310	0.112	0.106	0.111	0.115	0.548	0.532
	20 %	0.499	0.506	0.208	0.212	0.175	0.184	0.883	0.903
	30 %	0.884	0.872	0.346	0.361	0.429	0.449	1.660	1.683
	40%	0.720	0.710	0.292	0.297	0.300	0.305	1.313	1.314
LSD at 0.05 level		**0.034**	**0.033**	**0.015**	**0.017**	**0.017**	**0.028**	**0.033**	**0.046**

* Sewage sludge was applied by mixing it at different tested rates with the sandy planting medium before eucalyptus seedling transplanting.

of P uptake in stem for two seasons (1.028 and 1.027 g/ kg DW) and total uptake (1.809 and 1.818 g/kg DW).

4.2. Uptake and total uptake of potassium

Tabulated results in Table 8 show that the highest value of K uptake in stem was recorded in *E. gomphocephala* (8.412 and 8.178 g/ kg DW in the 1st and 2nd seasons, respectively). Also, the same specie recorded the highest value of total uptake of K (16.065 and 15.482 g/kg DW in the 1sat and 2nd seasons, respectively). These differences in minerals uptake among the three species might be mainly due to the heredity differences.

Plantation of seedlings in mixture of sewage sludge at 30 % + sandy soil at 70 % recorded the highest value of K uptake in all plant organs (10.090 and 9.937 g/ kg DW for stem, 5.042 and 5.222 g/ kg DW in leaves, 5.631 and 5.187 g / kg DW in roots in the 1st and 2nd seasons, respectively), also the same mixture medium recorded higher total K uptake (Table 8).

The interaction between *E. gomphocephala* and plantation in mixture medium of 40% sewage sludge + 60 % sandy soil (Table 8) gave the highest values of K uptake in stem, (14.092 and 13.267 g/ kg DW in the 1st and 2nd seasons, respectively) and total K uptake (28.176 g/kg DW in the 1st season). While the interaction between *E. camaldulensis* and plantation in sandy soil containing sewage sludge at 30 % gave the highest total K uptake in the 2nd season only (27.033 g/kg DW).

However, such results are in agreement with those obtained by Talli and Riipera (1996) determining N, P and K contents in some ornamental trees; Androde and Mattizzo (2000) on *Eucalyptus grandis* applying sewage sludge at 10, 20 and 40 ton/ *ha* and determined N concentration in leaves; Ya *et al*. (2001) recorded total N, P and K in plant tissues of *Sesbania rostrata* and *S. cannabian*; and El-Settawy and El-Harriry (2009) on some woody trees, evaluated N, P and K percentages in leaf tissues . They concluded that sewage sludge applications significantly increased N, P and K content in plant organs.

3. Translocation factor (TF) ratio of N, P and K within plant organs

Data in Table 9 showed that, *E. citriodora* recorded highest value of translocation factor (TF) of nitrogen in leaves (1.32 and 1.26) in the 1st and 2nd seasons, respectively). While *E. gomphocephala* recorded the highest values of TF of P in leaves (1.062) in the 1st season and TF of K in leaves (1.14) in the 2nd season.

Plantation of eucalyptus seedling in 100 % sandy soil without sewage sludge recorded the highest value of TF of N in leaves (1.32 and 1.28 % in the 1st and 2nd seasons, respectively) and highest value of phosphorus TF (1.070 in the 1st season only). On the other hand, plantation of seedlings in

Table 8. Effect of plant species, sewage sludge applications and their interactions on K uptake by different plant organs and total uptake/ plant (g /kg DW) of *Eucalyptus species* during 2008/09 and 2009/10 seasons

Characters / Treatments		K uptake (g/ kg DW)						Total K uptake (g/ kg DW)	
		Stem		Leaves		Root			
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Effect of *Eucalyptus species*:									
E citriodora		2.315	2.184	1.684	1.622	0.927	0.954	4.927	4.760
E. gomphocephala		8.412	8.178	3.362	3.403	4.281	3.900	16.056	15.482
E. camaldulensis		7.717	7.866	3.438	3.557	3.405	3.544	14.562	14.968
LSD at 0.05 level		**0.569**	**0.372**	**0.282**	**0.114**	**0.359**	**0.248**	**0.753**	**0.659**
Effect of sewage sludge levels*:									
0 %		1.726	1.833	0.923	0.893	0.872	0.926	3.522	3.652
10 %		3.311	3.367	1.479	1.463	1.369	1.476	6.160	6.306
20 %		5.517	5.484	2.603	2.640	2.183	2.166	10.305	10.291
30 %		10.090	9.937	5.042	5.222	5.631	5.187	20.765	20.348
40%		10.096	9.760	4.093	4.085	4.300	4.242	18.489	18.088
LSD at 0.05 level		**0.309**	**0.296**	**0.189**	**0.142**	**0.243**	**0.206**	**0.437**	**0.288**
Effect of interaction between *Eucalyptus species* and sewage sludge levels:									
E. citriodora	**0 %**	0.886	0.950	0.714	0.659	0.429	0.487	2.030	2.097
	10 %	1.436	1.416	1.116	1.057	0.624	0.608	3.178	3.083
	20 %	2.373	2.267	1.541	1.441	0.922	0.908	4.836	4.617
	30 %	3.336	3.222	2.957	2.948	1.385	1.481	7.679	7.653
	40%	3.543	3.065	2.091	2.004	1.275	1.284	6.910	6.353
E. gomphocephal	**0 %**	2.191	2.209	1.043	1.011	1.118	1.157	4.354	4.379
	10 %	4.425	4.570	1.769	1.799	2.016	2.295	8.210	8.665
	20 %	7.554	7.445	3.166	3.276	3.287	3.065	14.008	13.787
	30 %	13.797	13.402	5.983	6.166	8.395	6.788	28.176	26.357
	40%	14.092	13.267	4.850	4.763	6.588	6.194	25.531	24.225
E. camaldulensis	**0 %**	2.100	2.339	1.011	1.008	1.069	1.133	4.181	4.481
	10 %	4.072	4.114	1.552	1.531	1.467	1.524	7.092	7.170
	20 %	6.624	6.740	3.103	3.203	2.341	2.526	12.070	12.470
	30 %	13.137	13.188	6.187	6.553	7.113	7.291	26.438	27.033
	40%	12.652	12.948	5.338	5.490	5.037	5.247	23.028	23.685
LSD at 0.05 level		**0.537**	**0.512**	**0.329**	**0.245**	**0.420**	**0.357**	**0.757**	**0.499**

* Sewage sludge was applied by mixing it at different tested rates with the sandy planting medium before eucalyptus seedling transplanting.

of seedlings in mixture of sewage sludge at 30 % + sand at 70 % gave the higher TF of K in leaves (1.15 in 2nd season only).

As for interaction effects (Table 9), *E. citriodor*a planted in 100 % sandy soil recorded the highest value of nitrogen TF in leaves (1.57 and 1.51 in the 1st and 2nd seasons, respectively). While, plantation *E. camaldulensis* in the same medium (without sewage sludge) gave the highest value of P TF in stem (0.075 and 0.068 in the 1st and 2nd seasons, respectively). The interaction between the tested eucalyptus species X all sewage sludge application levels had no significant effect on TF of K in stem and leaves in both seasons.

Conclusively, it could be recommend that planting eucalyptus plants especially *E. gomphocephala* in new reclaimed sandy soils with using sewage sludge at rate of 30 or 40 % (mixing with soil w/ w) as untraditional fertilizer. This practice enhance plant growth and its uptake of the main essential elements (NPK) and permit a good chance to reduce or eliminate the risk of the environmental pollution resulted from sewage sludge.

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استخدام الحمأة لدفع نمو بعض أنواع الكافور النامية في أراض رملية حديثة الاستصلاح

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أجرى هذا البحث في المزرعة التجريبية لمحطة بحوث البساتين بالقصاصين- معهد بحوث البساتين- مركز البحوث الزراعية - مصر خلال الموسمين المتتاليين ٢٠٠٨/ ٠٩ ، ١٠/٢٠٠٩ بهدف تقييم تأثير الحمأة "رواسب الصرف الصحي الصلبة" على النمو والمحتوى الكيماوي لبعض أنواع الكافور (*Eucalyptus citriodora* ، *E. gomphocphala* ، *E. camaldulensis*) النامية تحت ظروف التربة الرملية ، خُلطت الحمأة بالوسط الرملي قبل زراعة الشتلات به بخمس مستويات وهى صفر ، ١٠ ، ٢٠ ، ٣٠ ، ٤٠ %.

أشارت النتائج المتحصل عليها إلى إعطاء نوع الكافور *E. gomphocphala* زيادات معنوية في قياسات النمو المختلفة " ارتفاع النبات ، سمك الساق ، الوزن الغض والجاف لكل من الأوراق و الساق والجزر مقارنةً بالنوعين *E. camaldulensis* ، *E. citriodora* ، كذلك سجل النوع *E. camaldulensis* أعلى القيم لمحتوى أجزاء النبات المختلفة من النسبة المئوية لعناصر النتروجين والفوسفور و البوتاسيوم.

سجلت النباتات المزروعة في خليط من ٣٠ % حمأة + ٧٠ % تربة رملية أعلى زيادات في كل قياسات النمو وفى الكميات الممتصة في أعضاء النبات المختلفة وفى إجمالي الممتص من عناصر ن ، فو ، بو ، أيضاً أنتج مستوى الحمأة ٤٠ % (٤٠ % حمأة + ٦٠ % تربة رملية) قيم مرتفعة من نسب عناصر الـ ن ، فو ، بو فى أعضاء النبات المختلفة.

بخصوص معاملات التفاعل ،،، سُجلت أعلى القيم لصفات النمو الخضري السابقة الذكر، الممتص والممتص الكلى من عناصر ن ، فو ، بو بواسطة أجزاء النبات المختلفة في نباتات النوع *E. gomphocephala* المزروع في بيئة مكونة من ٣٠ % حمأة + ٧٠ % تربة رملية ، أيضا امتصت نباتات النوع *E. camaldulensis* نسب عالية من عناصر ن ، فو ، بو في أعضائها المختلفة .

التوصيـــــة : من هذه النتائج بمكن التوصية بزراعة نباتات الكافور وخصوصاً النوع *E. gomphocephala* في الأراضي الرملية حديثة الاستصلاح بعد إمدادها بالحمأة بمعدل ٣٠ أو ٤٠ % حيث أدى ذلك إلى دفع نمو النباتات وزيادة الممتص من عناصر النمو الأساسية (ن ، فو ، بو) ، وسمح ذلك أيضاً بفرصة جيدة للتقليل من أو إزالة خطورة التلوث البيئي الذي قد ينتج عن الحمأة ، أيضاً أظهر كلا النوعين *E. camaldulensis* ، *E. citriodora* نمو مرضى في الأراضي الرملية المزودة بالحمأة.