EFFECT OF IRRIGATION WITH TREATED WASTE WATER ON SOME PHYSICAL AND CHEMICAL PROPERTIES OF CALCAREOUS SOIL AND ON GROWTH AND HEAVY METALS CONTENT OF SOME FODDER TREES

Journal

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ABSTRACT

A greenhouse experiment was carried out to study the effect of secondary treated waste water on some physical and chemical properties of calcareous soil (sandy clay loam in texture) and on the growth and accumulation of some nutrient elements and heavy metals contents of three fodder trees (*Acasia saligna, Acacia stenophylla and Ceratonia siliqua*). Data showed that using secondary effluent in irrigation have an improving effect on soil physical and chemical properties which enhanced fodder trees growth. Results of the studied soil physical properties showed that percentage of macro water stable aggregates, optimum size aggregate, mean weight diameter (MWD) and structure coefficient (SC), as well as water holding pores and fine pores significantly increased by prolonged irrigation with secondary effluent up to 18 months, compared with tap water under the studied trees. While values of fine water stable aggregates (<0.25mm), quickly drainable pores and the specific surface area decreased. Results of soil chemical analysis indicated that soil pH, decreased and EC values slightly increased, while SAR did not varied by using secondary effluent as a source of irrigation. Soil available N, P and K, as well as Fe, Mn, Zn and Cu and heavy metals (Pb, Cd, Cr and Ni) increased with using secondary effluent as a source of irrigation.

Vegetative growth parameters (height, stem diameter, fresh and dry weight) and elements content in leaves of the three tree species (N, P, K, Fe, Zn, Mn, Cu, Pb, Cd, Cr and Ni) increased with prolonged irrigation period by secondary effluent comparing with tap water (control). The response of trees growth to irrigation with secondary effluent was in the order; *Acacia stenophylla* > *Acacia saligra* > *Ceratonia siliqua*. Content of both micronutrient and heavy metals in leaves of trees were within the permissible limits and below the toxic level, which encourage using such water for fodder trees irrigation under the conditions of the present study. *Acacia stenophylla* was the most responded tree for irrigation with secondary effluent. So, it is recommended to be planted in calcareous soil in western coastal region, instead of wasting such water in the sea.

Key words: irrigation, waste water, calcareous soil, heavy metals, fodder trees

INTRODUCTION

It is imperative to reuse the treated municipal wastewater in the agricultural expansion to face the scarcity of water resources, as well as the rapid population growth in Egypt. Also for protecting public health and controlling water pollution. The secondary treated municipal wastewater annual volume of Alexandria city amounts about 1.4 billion m^3 discharge to Maryout lake and ultimately discharge to the Mediterranean see (Abd El-Naim, 1995). This treated wastewater can be use as an unconventional resource for irrigating the desert area in the north western coast of Egypt. The most area of these soils is calcareous in nature and depends manly on rainfall in its cultivation.

Using this treated water in cultivating fodder trees will solve the problem of seasonal feed shortage resulted from the unstable rainfall conditions predominated in such areas besides improving the physical, chemical and biological properties of soils. At the same time save and economic getting rid of this unconventional resource of water instead of wasting it in the sea water.

Leguninous trees and shrubs are good fodders source, particularly towards the end of dry seasons. But, overgrazing and fuel wood cutting have deleted wood lands and there is an urgent need to plant such multipurpose trees in order to increase the availability of browses, specially in new reclamined land to fill the gap of shortage of some green forages. So, using Leucaena, Tipuna and Acacia species can be recommended as promising fodder plants in the new reclaimed land irrigated by wastewater to improve animal productivity in the north coast of Egypt (Hafez and Hassan, 2001). Several Acacia spp. have been introduced from Australia into Africa and the near east (El-Lakany, 1987) of which Acacia saligna is regarded as the most important introduced species to the western coast of Egypt as multipurpose shrub.

So, the objective of the present work was to investigate the effect of irrigation with secondary treated wastewater on some physical and chemical properties of calcareous soil and on the growth and some nutrient elements and heavy metals contents of three fodder trees: Acasia saligna, Acacia stenophylla and Ceratonia siliqua.

MATERIALS AND METHODS

A pot experiment of complete randomized block design with six replicates was conducted using cylindrical perforated plastic pots (30 cm height x 34 cm diameter) containing 22 kg soil. The experiment was carried out in the greenhouse at soil salinity laboratory, Agric. Res. Center, Alex., Egypt, during the period from Sept. 2000 to March 2002. The experimental soil represent a calcareous soil with 30.0% $CaCO_3$ was collected from surface layer (0 – 30cm) at Borg El-Arab city at north western coast area. The soil consist of 68.23% sand, 20.31% silt and 11.46% clay and had a sandy clay loam texture, pH of 7.94, EC value 3.08 dSm^{-1} .

Nine months old seedlings of three tree species, *Acasia saligna, Acacia stenophylla and Ceratonia siliqua* were planted and irrigated periodically for 18 months with an amount of water at each irrigation event to reach soil moisture content at field capacity. The secondary effluent obtained from Alexandria west treatment plant. The average composition of the secondary effluent used in irrigation is given in table 1. In general, the concentration of micronutrient, heavy metals, biochemical oxygen demand (BOD_5) and fecal coliform of the secondary effluent used in irrigation is less than the maximum permissible limits given by F.A.O. (1985) and W.H.O. (1989). The pH values as that of EC and SAR are in the normal range.

The experimental treatments were (1) irrigation with secondary treated wastewater and tap water for control, (2) three timber tree species used as fodder, i.e. *Acasia saligna, Acacia stenophylla and*

Ceratonia siliqua, (3) three prolonged irrigation periods, i.e., 6, 12 and 18 months from trees transplanted. Irrigation water was added periodically with an amount of water at each irrigation event to reach soil moisture content at field capacity.

Table 1: Chemical analysis of the used irrigation water

	Second. Effluent	Tap Water
Parameter	**Mean values**	
	Second. effluent	**Tap water**
pH value	07.80	07.50
EC dS m^{-1}	01.93	00.47
Soluble cations meq L^{-1}		
Ca^{2+}	06.55	01.82
Mg^{2+}	04.60	01.28
Na^{+}	07.21	01.40
K^{+}	00.86	00.14
Soluble anions meq L^{-1}		
CO_3^{2-}	00.00	00.00
HCO_3^{-}	08.50	02.90
Cl^{-}	09.64	01.62
SO_4^{2-}	1.08	00.12
SAR	03.05	00.12
Total suspended soils mg L^{-1}	17.86	00.00
Total dissolved solids mg L^{-1}	85.20	00.00
BOD_5 mg L^{-1}	19.00	00.00
NH_4-N mg L^{-1}	22.76	00.94
NO_3-N mg L^{-1}	00.92	00.26
Total P mg L^{-1}	03.90	00.01
Total micro elements mg L^{-1}		
Fe	00.51	00.27
Cu	00.04	00.01
Zn	00.12	00.00
Mn	00.11	00.03
Pb	00.05	00.03
Cd	00.02	00.01
Ni	00.09	00.01
Cr	00.01	Not detected
Total coliforme (MPN/ 100ml)	29.00	00.00

Analytical methods

Irrigation water analyses were performed according to APHA (1995).

Soil physical analysis: soil aggregation by wet sieving technique was carried out to determine the aggregate size distribution according to Klute (1986). The aggregate parameters; mean weight diameter (M.W.D), optimum size aggregates according to Baver et al. (1972). Structure coefficient values (SC) according to EI-Shafei and Ragab (1975). Pore size distribution was calculated from pFcurves according to De Leenher and De Boodt (1965). Specific surface area was determined spectrophotometrically by the adsorption of one monomolecular layer of ortho-phenanthroline monohydrate according to Lawrie (1961).

Soil chemical analysis: pH, EC and available macronutrient was determined according to Page et. (1982). Available microelements (Fe, Mn, Zn, Cu, Pb, Cd and Ni) were extracted by 0.05 M DTPA solution according to Lindsay and Norvell (1978) and were measured by the atomic absorption spectrophotometer.

Plant analysis: the ground leaves samples were analyzed for N, P, K, Fe, Zn, Mn, Cu, Pb, Cd, Ni and Cr. Nitrogen was determined by the kjeldahl method (Rowell, 1994). For other chemical analyses, 1g of dried leaves was wet digested as described by (Rowell, 1994). Phosphorus was measured colorimetrically by ammonium molybdate method; while potassium was determined flamphotometrically (Jackson, 1973) Micro and trace elements were determined in the acid digest solution by atomic absorption Model 3300 Prkin Elmer.

RESULTS AND DISCUSSION

1- Soil physical properties

Water stable aggregates and aggregation parameters

Percentage of the macro water stable aggregates (> 2.0 mm) as showing in table (2), significantly increased, whereas percentage of the fine water stable aggregates (< 0.25 mm) significantly decreased with using secondary effluent as a source of irrigation water compared with tap water, as well as, by prolonged irrigation period. This is due to the organic materials content of secondary effluent which binds soil particles into aggregates of high stability. The aggregation parameters i.e. mean weight diameter, optimum size aggregate and structure coefficient increased significantly by using secondary effluent as a source of irrigation water compared with the tap water, as well as, by the prolonged irrigation period up to 18 months from tree plantation as shown in table (2). This observed trend was the same under all the studied tree species. These obtained results are in accordance with those of Ramadan and El-Fayoumy (2002).

Table 2: effect of irrigation with secondary effluent on some physical properties of soil after different period from tree plantation

Period from Trans-plantation	M. W.S.A.% >2.0 mm		m. W.S.A.% <0.25% mm		M.W.D mm		O.S.A.% 0.5 - 2.0 mm		S.C.	
	Tap water	Second. effluent	Tap water	Second. effluent	Tap water	Second. effluent	Tap water	Second. effluent	Tap water	Second. effluent
	Acacia saligna									
6 months	30.45c	37.05c	69.55a	62.95a	0.465c	0.482c	13.463c	18.897c	0.438c	0.589c
12 months	32.92b	42.41b	67.08b	57.50b	0.476b	0.494b	15.010b	23.655b	0.491b	0.737b
18 months	47.75a	42.10a	62.25c	57.90c	0.497a	0.506a	17.511a	28.225a	0.583a	0.914a
	Acacia stenophylla									
6 months	30.31c	37.14c	69.69a	62.86a	0.487c	0.402c	14.183c	20.055c	0.435c	0.591c
12 months	32.98b	43.19b	67.02b	56.81b	0.499b	0.513b	15.787b	23.585b	0.492b	0.761b
18 months	37.20a	49.19a	62.80c	50.81c	0.517a	0.526a	18.858a	29.838a	0.592a	0.851a
	Ceratonia siliqua									
6 months	30.24c	35.93c	69.76a	62.08a	0.466c	0.466c	13.199c	19.603c	0.433c	0.561c
12 months	32.68b	42.23b	67.32b	57.77b	0.477b	0.477b	14.689b	23.381b	0.485b	0.731b
18 months	36.01a	47.70a	64.00c	52.30c	0.475a	0.490a	17.073a	28.081a	0.563a	0.912a

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

M.W.S.A. = Macro water stable aggrigate,

m.W.S.A. = Micro water stable aggregate,

M.W.A. = Mean weight diameter,

O. S. A. = Optimum size aggregate,

S.C. = Structure coefficient.

Pore size distribution

Data showed that, it was widely affected by secondary effluent (table 3), quick drainable pores (>28.8μ in diameter) decreased significantly by prolonged irrigation with secondary effluent up to 18 months, while irrigation with tap water had no significant effect at all periods. The slowly drainable pores (28.8μ - 8.62μ in diameter), the water holding pores (18.62 – 0.19 μ) and the fine pores (< 0.19 μ) increased significantly by using secondary effluent as a source of irrigation water compared with tap water, as well as, by the prolonged irrigation period up to 18 months. The increment of the water holding pores indicates more plant available water in the soil irrigated with secondary effluent than in the soil irrigated with tap water. The obtained results were in agreement with those obtained by Abd El-Naim et al. (1986) and (1987).

Table 3: Effect of irrigation with secondary effluent on pore size distribution and specific surface area after different periods from trees transplantation.

Period from transplantation	Q.d.p		S.d.p		W.h.p		F.p		Specific surface area $m^2\ g^{-1}$ soil	
	Tap water	Second. effluent	Tap water	Second. effluent	Tap water	Second. effluent	Tap water	Second. effluent	Tap water	Second. effluent
Acacia saligna										
6 months	20.972a	20.560a	6.920a	7.948c	9.450a	10.120c	9.702a	10.434c	307.19a	289.35a
12 months	20.952a	19.932b	6.914a	8.598b	9.468a	10.286b	9.732a	11.836b	304.53b	284.12b
18 months	20.944a	19.620c	6.928a	8.970a	9.484a	12.972a	9.754a	12.912a	302.26c	278.47c
Acacia stenophylla										
6 months	20.944a	20.544a	6.918a	7.958c	9.460a	10.130c	9.734a	10.472c	306.68a	288.90a
12 months	20.924a	19.904b	6.920a	9.062b	9.470a	10.308b	9.746a	11.862b	304.03b	283.63b
18 months	20.910a	19.572c	6.902a	9.450a	9.526a	13.006a	9.794a	12.934a	301.77c	277.87c
Ceratonia siliqua										
6 months	20.984a	20.590a	6.936a	7.940c	9.422a	10.112c	9.694a	10.406c	308.10a	290.88a
12 months	20.976a	19.944b	6.912a	8.560b	9.448a	10.276b	9.712a	11.794b	305.51b	285.67b
18 months	20.962a	19.650c	6.924a	8.904a	9.468a	12.956a	9.730a	12.884a	303.22c	279.91c

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

Q.d.p. = Quickly drainable pores (>28.8µ),
S.d.p. = Slowly drainable pores (28.8- 8.62µ),
W.h.p = Water holding pores (8.62 -0.19 µ),
F.p. = Fine pores (< 0.19 µ).

Specific surface area

As shown in table (3), secondary effluent application significantly decreased the specific surface area (SSA) comparing to using tap water for irrigation under all tree species. This may be attributed to the beneficial effects of organic materials content of secondary effluent which improve the aggregation properties of the soil and cause the increase in diameter of soil particles. It is well known that, the smaller the diameter of particles the bigger is the SSA (Hillel, 1982).

On the other hand, tree plantation led to an increase in SSA with using tap water (control) as a source of irrigation as compared to SSA of the soil before plantation. The recorded value was 287.68 m^2g^{-1}before plantation, whereas the value after trees plantation were 307.33, 304.36 and 302.42m^2g^{-1} in the case of using tap water as a source of irrigation after 6.12 and 18 months, respectively. The recorded values in the case of using secondary effluent as a source of irrigation was 289.71, 284.48 and 278.74m^2g^{-1} after 6, 12 and 18 months respectively. These results are in agreement with those obtained by Abd El-Kader (1998).

2- Soil chemical properties

As shown in table (4), irrigation with secondary effluent resulted in slight decrease in soil pH, while EC value slightly increased. Sodium absorption ratio (SAR) did not varied by using secondary effluent as a source of irrigation water compared with the tap water. These obtained results are in agreement with those of Neilsen et al. (1991), Farag (2000). Available nitrogen, phosphorus and potasium in soil increased by using secondary effluent as a source of irrigation water compared with tap water, as well as, with the extended irrigation period from 6 months to 18 months. The results are in agreement with those obtained by Pell and Nyberg (1989), Hayes et al. (1990). Also, Fe, Mn, Zn and Cu increased by using secondry effluent comparing to using tap water for irrigation. These micronutrients increased in soil as follow: Cu > Mn > Fe > Zn.

This increment in micronutrient elements may manifest the economic effect of using secondary effluent as a source of irrigation in increasing the DTPA extractable micronutrients. For all the four micro-nutrient elements, the increament percentage with the period from tree plantation up to 18 months indicate possibility to reach toxic levels with time. Heavy metals, namely Pb, Cd, Cr and Ni contents in soil increased by using secondry effluent as a source of irrigation compared with tap water and increased with the prolonged irrigation period from 6 to 18 months.

DTPA extractable Cd and Cr increased to 80% and 180%, respectively, while Ni and Pb doubled with prolonged application of secondary effluent. Many workers stated that heavy metals accumulated in soil as a result of using sewage effluent for irrigation (Aboulroos et al., 1989, Hopmans et al. 1990 and Al-Atrash, 2002).

Table 4: Effect of irrigation with secondary effluent on some chemical properties of the cultivated soil after different periods from trees transplantation.

Period from transplantation	Irrigation water type	pH (1:2.5)	EC dSm^{-1}	SAR	Macro-elements mg kg^{-1}			Micro-elements mg kg^{-1}				Heavy metals mg kg^{-1}			
					N	P	K	Fe	Zn	Mn	Cu	Cd	Pb	Cr	Ni
Acacia saligna															
6 months	Tap water	7.89	3.04	2.73	10.09	6.08	15.15	0.59	0.23	1.90	2.26	0.08	n.d	n.d	0.07
	Second. effluent	7.86	3.25	2.97	15.44	12.25	22.48	1.03	0.58	2.53	3.36	0.15	0.05	0.08	0.15
12 months	Tap water	7.88	3.05	2.73	12.28	7.13	16.05	0.90	0.32	2.43	2.54	0.11	n.d	n.d	0.05
	Second. effluent	7.79	3.33	3.07	18.93	15.76	25.34	1.39	0.64	3.28	3.94	0.27	0.09	0.12	0.14
18 months	Tap water	7.85	3.04	2.72	13.01	8.89	16.37	1.30	0.38	2.80	2.91	0.09	n.d	n.d	0.04
	Second. effluent	7.67	3.40	3.10	21.16	17.18	27.06	1.86	0.84	3.92	4.11	0.41	0.14	0.16	0.18
Acacia stenophylla															
6 months	Tap water	7.91	3.05	2.71	10.12	6.10	15.15	0.63	0.26	1.94	2.50	0.08	n.d	n.d	0.08
	Second. effluent	7.87	3.25	2.98	15.44	12.28	22.52	1.12	0.61	2.54	3.60	0.19	0.07	0.10	0.15
12 months	Tap water	7.93	3.04	2.75	12.29	7.15	16.03	0.97	0.34	2.44	2.87	0.09	n.d	n.d	0.09
	Second. effluent	7.79	3.34	3.07	18.94	15.86	25.34	1.41	0.66	3.35	3.91	0.32	0.10	0.14	0.17
18 months	Tap water	7.93	3.04	2.72	13.04	8.90	16.38	1.33	0.43	2.84	3.13	0.11	n.d	n.d	0.14
	Second. effluent	7.66	3.39	3.09	21.17	17.21	27.08	1.88	0.87	3.94	4.28	0.45	0.18	0.14	0.23
Ceratonia siliqua															
6 months	Tap water	7.89	3.05	2.73	10.19	6.09	15.20	0.66	0.25	1.96	2.50	0.09	n.d	n.d	0.09
	Second. effluent	7.87	3.25	2.97	15.45	12.29	22.53	1.16	0.59	2.57	3.59	0.20	0.06	0.11	0.17
12 months	Tap water	7.87	3.05	2.73	12.28	7.17	16.08	0.99	0.33	2.47	2.88	0.10	n.d	n.d	0.09
	Second. effluent	7.79	3.33	3.07	18.97	15.89	25.37	1.44	0.65	2.35	3.92	0.34	0.12	0.14	0.19
18 months	Tap water	7.84	3.04	2.72	13.04	8.94	16.40	1.33	0.40	2.84	3.10	0.12	n.d	n.d	0.16
	Second. effluent	7.68	3.39	3.11	21.20	17.17	27.10	1.90	0.86	3.95	4.28	0.47	0.20	0.19	0.25

3- Tree growth

Data in table (5) showed that prolonged used of secondary effluent in irrigation led to an increase in all the studied growth parameters; plant height, stem diameter, fresh and dry weight of leaves, stems and roots, relative to irrigation with tap water. The increment percentage in plant height of Acacia saligna was 140% after 6 months from plantation and doubled to 374.27% after 18 months. The least one in its affect was for Ceratonia siliqua, where the increment percentage in plant height was 85.88% and 203.69% after 6 and 18 months from plantation, respectively.

The average percentage of height growth increment during the study period under irrigation with secondary effluent was 248.2%, 153.1% and 145.6% respectively for Acacia saligna, Acacia stenophylla and Ceratonia siliqua. These results indicate that Acacia saligna gave the heighest response to irrigation with wastewater in height compared with other tree species. The stem diameter for Acacia stenopylla was higher than those of Acacia saligna and Ceratonia siliqua.

Table 5: Effect of irrigation with secondary effluent on some growth characteristics of studied trees after different periods from trees plantation.

Period from transplantation	Irrigation water type	Plant Height cm	Height Growth Increasement %	Stem Diameter mm	Stem Diameter Increasement %	Fresh weight (g. plant^{-1})			Dry weight (g. plant^{-1}		
						Leaves	Stems	Roots	Leaves	Stems	Roots
Acacia saligna											
6 months	Tap water	64.00	100.00	11.17	153.86	61.30	75.60	60.48	48.98	64.36	53.68
	Secondary effluent	77.07	140.83	14.05	219.32	81.87	90.88	87.45	63.89	36.80	77.04
12 months	Tap water	84.35	163.60	14.15	221.59	93.24	101.88	90.01	70.50	89.93	77.75
	Secondary effluent	105.52	229.74	18.17	318.56	111.96	104.03	103.20	88.27	92.42	89.54
18 months	Tap water	117.47	276.08	18.78	326.89	122.67	115.60	106.43	96.73	103.93	92.09
	Secondary effluent	151.77	374.27	24.60	459.09	151.47	128.83	121.93	110.73	114.23	109.23
Acacia stenophylla											
6 months	Tap water	61.97	47.53	11.53	401.45	112.12	63.37	55.72	83.08	59.93	50.68
	Secondary effluent	85.12	102.65	14.32	522.46	156.76	131.98	93.60	122.32	110.93	79.21
12 months	Tap water	72.58	72.82	14.60	534.78	135.44	104.77	74.66	106.83	91.62	67.05
	Secondary effluent	105.50	151.19	18.95	723.91	188.73	174.19	157.76	145.21	144.19	141.68
18 months	Tap water	85.80	104.29	20.67	798.55	157.20	130.42	110.56	122.39	107.59	102.00
	Secondary effluent	128.27	205.40	22.78	890.58	228.15	214.28	211.03	176.08	178.83	188.22
Ceratonia siliqua											
6 months	Tap water	30.85	62.37	9.65	25.75	26.96	26.14	20.52	14.13	14.43	11.65
	Secondary effluent	35.32	85.88	11.40	32.22	42.31	39.86	31.13	22.27	21.76	17.87
12 months	Tap water	38.53	102.81	11.60	32.96	31.02	31.85	26.82	14.17	17.25	15.07
	Secondary effluent	46.98	147.28	13.70	40.74	51.78	49.78	42.25	26.57	27.19	24.72
18 months	Tap water	45.47	139.39	14.13	42.34	36.47	38.47	33.44	17.30	20.64	19.65
	Secondary effluent	57.70	203.69	17.97	56.56	61.93	61.23	53.08	29.98	32.73	30.76

The average increment percentage in stem diameter during the study period under irrigation with secondary effluent were 712.3%, 332.3%, and 43.1%, respectively for Acacia stenophylla, Acacia saligna, and Ceratonia siliqua. This means that Acacia stenophylla had the highest reponse to wastewater irrigation in diameter and that Ceratonia siliqua had the least one. Hassan et al. (2003) found considerable differences in growth parameters; hight, diameter and stem volume of Acacia saligna, Albizial ebbek, Melia azedarach, Tipuana species and Taxodium disticum, grown in Borg EL Arab city and irrigated with sewage effluent. Similar results were also found by Hopmans et al. (1990), using seven tree species irrigated with municipal effluent at Wodongam Australia.

The three tree species differed in their response of fresh weight of leaves, stems and roots to irrigation with secondary effluent. Acacia stenophylla gave the highest response and the highest fresh weight, followed by Acacia saligna. While Ceratonia siliqua was the least one in its effect by the irrigation with secondary effluent. The same trend was observed for the dry weight of the three studied trees.

Elements content in tree leaves

As shown in table (6), content of the macronutrients N, P and K in leaves of the studied tree species increased by using secondary effluent as a source of irrigation compared with tap water, as well as, the prolonged irrigation period up to 18 months. This observed trend was the same under all the studied tree species. The tree species were varied in their content of these elements. The increment of the aforementioned macronutrients in tree species followed the order: Ceratonia siliqua > Acacia stenophylla > Acacia saligna. Generally, the concentration of N P K in leaves of the three tree species was in the following order: N > K > P. The same results were obtained by Hassan et al., (2003) using five tree species and Hopmans et al., (1990) using seven tree species.

Micronutrients; Fe, Zn, Mn, and Cu, content in leaves of tree species increased by using secondary effluent as a source of irrigation compared with tap water as well as the prolonged irrigation period up to 18 months (table 6). The content of these elements varied between the studied tree species. Content of Fe and Mn in leaves of Ceratonia siliqua was higher than in leaves of Acacia saligna and Acacia stenophylla. Acacia stenophylla had the highest content of Cu. Content of Zn in leaves of acacia saligna was higher than that in leaves of acacia stenophylla and ceratonia siliqua. The concentrations of these elements were not outside the range of normal levels.

Concerning the heavy metals concentrations in leaves of the studied tree species, data in table (6) revealed that the determined heavy metals ; Pb, Cd, Cr and Ni slightly increased by using secondary effluent as a source of irrigation compared with tap water. The highest increase was observed for Pb concentration in acacia saligna. It was 6.22, 7.64, and 11.05 mg after 6, 12 and 18 months form plantation. The content of Cd was very low in all trees as well as Cr and Ni. The concentrations of Cr and Ni were very low and were not detected after 6 months. However, the concentration of the heavy metals in the tree species was less than the permissible limits. Similar results indicated that heavy metals accumulation due to sewage irrigation was varied according to tree species as reported by Hopmans et al. (1990) and Hassan et al. (2003). The concentration of heavy; etals in the studied trees species was in the following order: Acacia saligna > Acacia stenophylla > Ceratonia siliqua.

Table 6: Effect of irrigation with secondary effluent on macro, micro-elements and heavy metals concentration in leaves of studied trees after different periods from trees plantation.

Period from transplantation	Irrigation water type	Macro-elements (% of dry weight)			Micro-elements (ppm)				Heavy metals (ppm)			
		N	P	K	Fe	Zn	Mn	Cu	Pb	Cd	Cr	Ni
Acacia saligna												
6 months	Tap water	2.720	0.083	0.622	111.58	17.91	28.81	31.24	3.25	0.18	n.d	n.d
	Second. effluent	3.093	0.173	0.812	123.17	27.68	42.41	38.87	6.22	0.26	n.d	n.d
12 months	Tap water	2.835	0.112	0.650	123.52	20.68	38.62	36.35	3.90	0.23	n.d	n.d
	Second. effluent	3.270	0.195	0.943	128.92	33.53	46.11	50.13	7.64	0.36	0.07	0.09
18 months	Tap water	2.853	0.142	0.790	127.33	24.14	34.39	41.64	4.40	0.33	0.13	0.08
	Second. effluent	3.368	0.230	1.173	137.83	35.80	51.32	71.35	11.05	0.43	0.17	0.15
Acacia stenophylla												
6 months	Tap water	2.905	0.097	0.657	107.50	16.64	25.71	30.12	2.51	0.12	n.d	n.d
	Second. effluent	3.117	0.185	0.868	122.17	20.19	27.53	39.54	4.63	0.21	n.d	n.d
12 months	Tap water	2.863	0.132	0.703	114.50	19.26	29.15	35.78	3.15	0.16	n.d	n.d
	Second. effluent	3.302	0.230	0.993	120.30	31.27	33.69	48.97	7.11	0.26	0.03	0.03
18 months	Tap water	2.892	0.160	0.835	120.25	22.29	32.95	40.87	4.03	0.23	0.11	0.10
	Second. effluent	3.402	0.252	1.230	137.83	32.96	38.74	70.88	10.65	0.34	0.13	0.15
Ceratonia siliqua												
6 months	Tap water	2.790	0.115	0.603	109.17	16.03	31.86	28.27	2.44	0.08	n.d	n.d
	Second. effluent	3.143	0.208	0.895	123.17	19.37	41.23	36.48	4.54	0.17	n.d	n.d
12 months	Tap water	2.863	0.140	0.735	116.33	18.38	33.52	33.73	2.96	0.13	n.d	n.d
	Second. effluent	3.330	0.248	1.250	127.59	30.18	46.46	47.74	6.14	0.28	0.02	0.03
18 months	Tap water	2.932	0.183	0.862	121.33	21.27	35.26	39.79	3.36	0.22	0.09	0.08
	Second. effluent	3.440	0.280	1.278	139.33	31.96	51.48	55.53	9.81	0.38	0.14	0.11

In conclusion, using secondary effluent in irrigation have an impoving effect on soil physical and chemical properties, which enhanced fodder trees growth (Acacia saligna, Acacia stenophylla and Ceratonia siliqua). Content of both micronutrient and heavy metals in leaves of trees were within the permissible limits and below the toxic level, which encourage using for such water for fodder trees irrigation. Moreover, tree species that selected for this study differed in their growth and elements content. Acacia stenophylla was the most responded tree for irrigation with secondary effluent. So, it is recommended to be planted in calcareous soil in western coastal region, instead of wasting such water in the sea.

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تأثير الرى بمياه الصرف الصحى المعالجه ثانوياً على بعض خواص التربه الفيزيائية والكيميائية والنمو ومحتوى المعادن الثقيلة لبعض اشجار العلف النامية فى ارض جيرية

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نفذت تجربة فى صوبه زجاجية لدراسة تأثير مياه الصرف الصحى المعالجة ثأنوياً على بعض الخواص الفيزيائية والكيميائية لارض جيرية (ذات قوام رملى طينى سلتى) وعلى النمو والمحتوى المعدنى من العناصر الغذائية والعناصر الثقيلة لثلاثة أشجار خشبية بقولية تستخدم كعلف هى اكاسيا ساليجيا ، اكاسيا ستينوفيلا ، سيراتونيا سيليكوا (الخروب) . وأوضحت نتائج الخواص الفيزيائية ان استعمال مياه الصرف الصحى المعالجة ثانوياً فى الرى لمدة 18 شهر بالمقارنة مع الرى بمياه الصنبور زيادة كل من نسبة التجمعات الأرضية الثابتة فى الماء الكبرى والمثلى ، معامل البناء ، متوسط القطر الموزون ، وزيادة كل من نسبة المسام المسئولة عن حفظ المياه بالتربه والمسام الصرفية البطيئة والمسام الدقيقة بينما انخفضت نسبة التجمعات الارضية الدقيقه ، نسبة المسام الصرفية السريعة ، مساحة السطح النوعى للتربة . واظهرت نتائج الصفات الكيميائية انخفاض قيم رقم الحموضة(pH) ، زيادة طفيفة فى التركيز الكلى للاملاح معبراً عنه بقيم التوصيل الكهربى لمستخلص عجينة التربة المشبعة (EC) . بينما لم تتغير كثيراً قيم نسبة الصوديوم الادمصاصية (SAR) . وايضاً زيادة المحتوى الميسر بالتربة من العناصر الغذائية الكبرى (النيتروجين ، الفوسفور ، البوتاسيوم) والعناصر الغذائية الصغرى (الحديد ، المنجنيز ، الزنك ، النحاس) ومن العناصر الثقيلة (الرصاص ، الكاديوم ، الكروم ، النيكل) .

وقد انعكس ذلك ايجابياً على نمو الاشجار فأظهرت نتائج الرى بمياه الصرف الصحى ، المعالجة ثانوياً لمدة 18 شهر ، زديادة النمو الخضرى للأشجار (الارتفاع ، قطر الساق ،الوزن الرطب والجاف) . وزيادة تركيز العناصر الغذائية الكبرى والصغرى والعناصر الثقيلة فى اوراق الاشجار مقارنة بالرى بمياه الصنبور . وكانت استجابة نمو الاشجار على الترتيب التالى :- اكاسيا ستينوفيلا > اكاسيا ساليجنا > سيراتونيا سيليكوا) . وكان تركيز العناصر الصغرى والثقيلة اقل من الحد المسموح به وتحت مستوى السمية بهذه العناصر مما يشجع استخدام مثل هذه المياه لرى اشجار العلف تحت ظروف الدراسة . لذا فانه يوصى بزراعة اشجار اكاسيا ستينوفيلا فى الاراضى الجيرية بالساحل الشمالى الغربى وريها بمياه الصرف الصحى المعالجة ثانوياً بدلا من صرفها فى البحر .