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EFFECT OF SOME SOIL TREATMENTS FOR REMEDIATION OF INJURIOUS IONS ON CARROT PLANT IRRIGATED WITH TREATED WASTE WATER

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ABSTRACT: *Two field experiments in 15[th] September 2003 and 2004 were conducted on an origin sandy soil in the experimental farm of El-Gabal El-Asfer at Kalubya Government. This study aimed to reduce the hazard effect of some injurious ions, as a result of irrigation with treated waste water, on carrot plant, using different soil treatments (Bacillus subtils, super phosphate calcium (SPC, at two rates viz. 250 and 500kg/fed.) and polyacrylamide hydrogel (PAMG)). The results revealed that a significant increase in plant fresh weight for the inoculation with Bacillus subtils, SPC at 250kg/fed. and PAMG treatments were observed as compared to the control. Also, a significant increase was achieved for storage root fresh weight as a result of application the Bacillus subtils. On other hand, Bacillus subtils treatment was found to have significantly lower Mn, Ni, Pb, Cd concentration in storage root compared to control. SPC1 (250kg / fed.) led to a significant decrease in Fe, Cu, Mn, Ni and Pb contents. Meanwhile, SPC2 (500 kg / fed.) significantly decreased Fe and Mn, but increased Ni, Pb and Cd contents over control. PAMG treatment gave a significant decrease in Mn and increase in Zn, Ni and Pb contents. The highest NO_3^- and NO_2^- concentrations were given by PAMG tretment but the lowest one was recorded by using Bacillus subtils .*

Keywords: *Carrot, Daucus carota, Bacillus subtils, super phosphate, polyacrylamide, waste water, Heavy metals, NO_3^-, NO_2^-.*

INTRODUCTION

The problem of suitable water for agriculture become on the top of world strategy importance, this problem developed and become the main subject in the century wars because the water needed for agriculture is not available in many countries specially in Africa. In general, available water in the world become insufficient for human requirements.

Waste disposal today is an important scientific, economic, social and political challenge in these environmentally conscious times. Egypt has begun a good program to reuse sewage in most of the cities in A.R.E (Sherif *et al* 2001).

The treated waste water was polluted by a lot of pathogenic microbes, higher amounts of the injurious ions such as toxic heavy metals (iron - copper - zinc -manganese - nickel - lead - cadmium and cobalt) and toxic nitrate. However, the accumulation of these injurious ions in the edible parts of crops irrigated with treated waste water and its translocation to human bodies when eating polluted crops caused a great danger on health. This problem increases when many farmers use raw waste water or treated waste water for irrigation of vegetable crops for daily consumption. So there is a necessary need to control this dangerous problem on health and environment (FAO, 2000).

Sewage sludge is a good source of organic matter and plant nutrients (Tisdale *et al* 1993). Great concern has been focused to the potential hazards of phytotoxic heavy metals which reach the soils and plants from various pollution sources such as sewage water (Omeran *et al* 1988; Elsokkary and Sharaf, 1996); sewage sludge (El-Shebiny and Khalifa, 2001; Elsokkary and El-Keiy, 1989) and atmospheric deposition (Mortvedt, 1987; Elsokkary, 1996). The use of sewage effluent and/or residual waters for the irrigation as well as the application of certain fertilizers constitute or sludge are considered one of the principal source of metal pollution especially cadmium in vegetables (Trimizi *et al* 1996).

Nitrate in plant tissues is more sensitive than total N to changes in N supply and the concentrations of NO_3^- increased linearly with increase in total N (El-Sayed, 1998). Nitrate accumulates in some kinds of plants, often under adverse growing conditions to the point that such plants are a hazard. Nitrate is reduced to nitrite (NO_2^-) in the rumen. Nitrites can also be produced in hay containing (NO_3^-) - if the hay gets damp. The concentration of NO_3^- in the soil after cropping legumes is higher than after non-legume crops; one reason is that they use less of the N released by mineralization of soil organic matter (Peoples *et al* 1995; Addiscott, 1996). Nitrate is a storage form of nitrogen in the plant and does not usually accumulate unless the total nitrogen level is high whereas the plant absorbs its N in the cationic NH_4^+ or anionic NO_3^-. Khatab (2001) indicated that the form concentrations of NO_3^- and NO_2^- were positively correlated with increasing nitrogen fertilizer rates.

Mehrotra and Lehri (1971); Lehri and Mehrotra (1972); Joi and Shinde (1976); Thilakavathy and Ramaswamy (1998); Daly *et al* (2000) and Mohamed and Hemida (2004) emphasized the beneficial effects on growth, uptake of nutrients, yield and quality of vegetable crops in response to biofertilization (Biogen). Meanwhile, the favourable effect of Biogen on growth parameters might be ascribed to its important role in fixing atmospheric N as well as increasing the secretion of natural hormones namely IAA, GA_3 and cytokinins, antibiotics and possibly raising the availability of various nutrients (Subba Rao, 1984; Thilakavathy and Ramaswamy, 1998; Daly *et al* 2000).

Beveridge (1989) focused his studies on the microbial morphology and incorporation of heavy metals; he concluded that the interaction between heavy metals and surface biological structures is inevitable. This surface accumulation occurs through chemical reactions such as complexation and ion-exchange with structural compounds present in the surface of microbes and other organisms (Da Costa, 1999). Incorporation is based on the polysaccharide composition of each particular organism, and is highly variable among distinct genera and even strains from the same species.

Rasheed *et al* (1997) indicated the beneficial effects of examined hydrogels as a new technique for sandy soils conditioning. The combination of physic-bio-chemical effects mentioned above leads to an increase in germination percent and rate as well as plant growth and dry matter production. A considerable reduction in the water consumption was obtained. Therefore, a significant improvement in the water use efficiency by plants was gained. The uptake of some macro-nutrients (N, P, and K) and micro- nutrients as (Fe, Mn, Cu and Zn) was increased. The produced yield by a unit of added nutrients referred to the beneficial effects of hydrogels for increasing the fertilizers use efficiency by plants grown in sandy soils.

The purpose of this study is to determine injurious ions accumulation by carrot roots grown in El-Gabal El-Asfer farm which irrigated with treated waste water, and to evaluate the effects of biofertilizer (*Bacillus subtils*), super phosphate calcium and polyacrylamide hydrogel as soil treatments on remediation or reduction the uptake of heavy metals.

MATERIALS AND METHODS

Two field experiments in 15^{th} September 2003 and 2004 were conducted on an origin sandy soil in the experimental farm of El-Gabal El-Asfer at Kalubya Government to reduce the hazard effect of some injurious ions as a result of irrigation by treated waste water in carrot plant, using different soil treatments, *Bacillus subtils*, super phosphate calcium (SPC) and polyacrylamide hydrogel (PAMG).

The experiments were arranged in a complete randomized block design with 3 replicates.

Soil and Treated Waste Water Analyses

Soil suspension and the treated waste water samples were taken to determine pH, electrical conductivity (EC), calcium carbonate (by Calcimeter apparatus according to Page *et al* 1982). Soluble cation and anion, macro- and micro-nutrients, heavy metals (Fe, Mn, Cu, Zn, Ni, Pb, Co and Cd by atomic absorption spectrophotometer). Mechanical and chemical analysis of the cultivation soil and the treated waste water were performed in Arid Land Agricultural Research Unit and the Central Lab. Fac. of Agric. Ain Shams Univ.

Some physical and chemical properties of the studied soil (from surface layer 20 - 30 cm) are shown in Table (1). Some characters of the treated waste water were determined as show in Table (2).

Table 1. Some physical and chemical analyses of the soil samples collected from El-Gabal El-Asfer farm.

Soil characteristic		Values
	S.P (%)	24
	pH at 1:2.5	7.82
	E.C (mmohs)	1.43 mmohs/cm
	$CaCO_3$ (%)	0.75
Mechanical analysis (%)		
	Sand	89
	Silt	10
	Clay	1
	Soil texture	Sandy soil
Soluble ions (meq/l)		
Cations:		
	Calcium	7.40
	Magnesium	2.60
	Sodium	4.80
	Potassium	0.45
Anions:		
	Carbonate	Zero
	Bicarbonate	3.50
	Chloride	2.00
	Sulphate	7.90
Nutrients		
	Nitrogen (ppm)	42.00
	Phosphorus (ppm)	16.48
	Potassium (ppm)	0.11
	Calcium (meq/l)	6.0
	Magnesium (meq/l)	4.0
Heavy metals content (ppm)		
	Iron (Fe)	52
	Manganese (Mn)	17.2
	Zinc (Zn)	9.40
	Copper (Cu)	7.01
	Nickel (Ni)	0.62
	Lead (Pb)	2.08
	Cadmium (Cd)	0.06
	Cobalt (Co)	undetected

Table 2. Some physical and chemical characteristics of waste water samples collected from El-Gabal El-Asfer station.

Waste water characteristic		Values
	Water pH	7.60
	Electrical Conductivity (E.C)	0.78 mmohs
Soluble ions (meq/l)		
Cations:		
	Calcium (Ca^{++})	4
	Magnesium (Mg^{++})	3
	Sodium (Na^{+})	4.5
	Potassium (K^{+})	0.4
Anions:		
	Carbonate (CO_3^{--})	Zero
	Bicarbonate (HCO_3^{-})	5.2
	Chloride (Cl^{-})	3.75
	Sulphate (SO_4^{-})	0.3
	Nitrate (NO_3^{-})	52.85
Nutrients:	(ppm)	
	Nitrogen (N)	50
	Phosphorus (P)	20
	Potassium (K)	60
Heavy metals content (ppm)		
	Iron (Fe)	0.53
	Manganese (Mn)	0.52
	Zinc (Zn)	0.13
	Copper (Cu)	1.50
	Boron (B)	0.4
	Nickel (Ni)	0.25
	Lead (Pb)	0.26
	Cobalt (Co)	0.15
	Cadmium (Cd)	0.004

Carrot (*Daucus carrota* L.) seeds cv. Shanttanii-Japan were obtained from Agricultural Research Center.

Soil Treatments

The total number of treatments reached 4 as follows:

1. Untreated plants (control, C) were irrigated by the treated waste water only.
2. Inoculated treatment with *Bacillus subtils* strains No. 13 (according to Reda *et al* 2004, Ministry of Agriculture and soil Reclamation). Inoculation of bacteria (BS) was added to soil before cultivation by rate 8 l/fed. Bacteria were applied at concentration of about 10^8 cells/ml liquid cultures. The biofertilizer obtained from Biofertilizer Unit, Microbiology Department Fac. of Agric. Ain Shams Univ.
3. Super phosphate calcium fertilizer (SPC) was added before cultivation with two rates, 250 kg/fed (SPC1) and 500 kg/fed (SPC_2).
4. Polyacrylamide hydrogel (PAMG) as a soil conditioner application was added on 10-15cm depth from surface layer by rate range from 50 to 80 kg/fed in open field. PAMG got from Pico Company for Agricultural Department (Florgir Market).

Growth Parameters

Plant samples in two seasons were taken at 90 days from sowing (harvest stage). The recorded growth parameters of carrot included plant length (cm), number of leaves/plant, plant fresh and dry weights (g/plant), as well as storage root length (cm), thickness (cm^2), fresh and dry weights (g/plant).

Chemical Analysis

At harvesting, samples of carrot roots were taken for chemical analyses. Heavy metals, nitrate and nitrite concentrations were determined.

-Heavy Metals

Half gram dried sample (at 70°C) was digested with concentrated sulfuric acid and H_2O_2 30 %at 120°C for 1 h according to the method described by Black *et al* (1965). Heavy metals (iron, manganese, copper, zinc, nickel, lead and cadmium) were assayed using atomic absorption spectrophotometer as reported by Chapman and Pratt (1961) Heavy metals were determined in Arid Land Agricultural Research Unit, Fac. Agric., Ain Shams Univ.

-Determination of Nitrate and Nitrite Concentration

Nitrate and nitrite were determined spectrophotometrically at 550 nm using the method of Nrisinha and Donalds (1978) and data were expressed as mg/l (ppm).

Data of growth, yield, heavy metals, nitrate and nitrite were statistically analyzed using SAS procedures (1996).

RESULTS AND DISCUSSION

Effect of soil treatments on growth and yield

Data presented in Tables (3-5) revealed the effect of soil treatments on growth parameters of carrot plant irrigated by treated waste water.

Regarding the effect of *Bacillus subtils* on plant length, number of leaves/plant, plant dry weight, storage root length, storage root thickness and storage root dry weight (Table 3), no significant differences were noticed. As shown in Table (3) *Bacillus subtils* had a significant increase upon plant and storage root fresh weights as compared to the control.

Data given in Table (4) show that, higher rate of the calcium super phosphate had no detectable effect upon growth parameters compared with control. On the other hand, SPC_1 recorded significant increase in plant fresh weight as compared either with SPC_2 or control.

As for polyacrylamide hydrogel (PAMG), It is evident from the data in Table (5) that it was significantly effective in increase plant fresh weight as compared to control.

The use of inoculation with biofertilizer (*Bacillus subtils*) led to improvement of plant growth (plant and storage root fresh weights) of carrot. The obtained results indicate that both treated waste water and inoculation acted together in enhancing plant growth. This could be due to that waste water is considered a source of both plant nutrients such as nitrogen and micronutrients. These together improve the fertility of the studied soil. In addition, this may be due to the role of nitrogen in stimulating the microbial activity for phytohormones formation and translocation to the plant. Indole acetic acid (IAA) cytokinins (CKs) and gibberellins (GAs) are known to play important role in plant apical dominance and to encourage new cell formation and to have important role in increasing photosynthetic rate. The increase in plant cell division, photosynthates accumulation and plant photosynthesis rate would result in increase in plant growth and development. Similar results were obtained by Subba Rao (1984); Atta-Allah (1998); Mishra *et al* (1998); Salem (2000); Saleh *et al* (2000); Aly (2003) and El-Nagar (2003).

Super phosphate calcium showed significant increase on plant fresh weight. Such results might be attributed to the essential role of phosphorus in plant growth and productivity (Mengel and Kirkby, 1987). SPC caused marked stimulative effects on plant growth. These increases may be due to the beneficial effect of P-element on the activation of photosynthesis and metabolic processes of organic compounds in plants and hence increasing plant growth (Gardener *et al* 1985; Abdel-Fattah and Abdel-Hameid 1997).

Table 3. Effect of *Bacillus subtilis* (BS) on some growth parameters of carrot plant irrigated with treated waste water in seasons 2003 and 2004 .

Treatment (T)	Plant length (cm)			No of leaves / plant			Plant fresh weight (g)			Plant dry weight (g)		
	1	2	Mean	1	2	Mean	1	2	Mean	1	2	Mean
Control	51.3	49.9	50.6	7.6	8.1	7.9	87.0	88.1	87.55 b	12.3	12.9	12.6
BS	49.8	51.0	50.4	8.0	8.3	8.2	92.6	94.2	93.4 a	13.5	11.0	12.3
Mean S	50.6	50.5		7.8	8.2		89.8	91.2		12.9	12.0	
MSD T 5%			NS			NS			1.51			NS
MSD S 5%			NS			NS			NS			NS

Treatment (T)	Storage root length (cm)			Storage root thickness (cm^2)			Storage root fresh weight (g)			Storage root dry weight (g)		
	1	2	Mean	1	2	Mean	1	2	Mean	1	2	Mean
Control	15.4	14.3	14.9	2.2	2.2	2.2	69.6	66.6	68.1 b	14.1	10.5	12.3
BS	14.6	14.7	14.7	2.6	2.5	2.5	71.6	82.2	76.9 a	12.1	14.4	13.3
Mean S	15.0	14.5		2.4	2.4		70.6	74.4		13.1	12.5	
MSD T 5%			NS			NS			2.62			NS
MSD S 5%			NS			NS			NS			NS

1 = first season 2 = second season

Table 4. Effect of super phosphate calcium (SPC) on some growth parameters of carrot plant irrigated with treated waste water in seasons 2003 and 2004 .

Treatment (T)	Plant length (cm)			No of leaves / plant			Plant fresh weight (g)			Plant dry weight (g)		
	1	2	Mean	1	2	Mean	1	2	Mean	1	2	Mean
Control	49.4	51.3	50.4	7.6	8.1	7.9	87.0	88.1	87.55 ab	12.3	12.9	12.6
SPC1	52.3	48.4	50.4	7.4	7.8	7.6	102.8	82.7	92.75 a	12.4	13.1	12.8
SPC2	48.4	52.3	50.4	7.4	7.6	7.5	78.2	85.5	81.85 b	12.6	12.3	12.5
Mean S	50.0	50.7		7.5	7.8		89.3	85.4		12.4	12.8	
MSD T 5%			NS			NS			10.23			NS
MSD S 5%			NS			NS			NS			NS

Treatment (T)	Storage root length (cm)			Storage root thickness (cm^2)			Storage root fresh weight (g)			Storage root dry weight (g)		
	1	2	Mean	1	2	Mean	1	2	Mean	1	2	Mean
Control	15.4	14.3	14.9	2.2	2.2	2.2	66.6	69.6	68.1	14.1	10.5	12.3
SPC1	14.0	15.8	14.9	2.3	2.6	2.5	69.0	60.1	64.6	12.7	12.7	12.7
SPC2	14.0	15.0	14.5	2.1	2.5	2.3	60.2	67.0	63.6	13.2	13.9	13.6
Mean S	14.5	15.0		2.2	2.4		65.3	65.6		13.3	12.4	
MSD T 5%			NS			NS			NS			NS
MSD S 5%			NS			NS			NS			NS

1 = first season 2 = second season
SPC1 = 250 Kg / fed SPC2 = 500 Kg / fed

Table 5. Effect of polyacrylamide hydrogel (PAMG) on some growth parameters of carrot plant irrigated with treated waste water in seasons 2003 and 2004 .

Treatment (T)	Plant length (cm)			No of leaves / plant			Plant fresh weight (g)			Plant dry weight (g)		
	1	2	Mean	1	2	Mean	1	2	Mean	1	2	Mean
Control	49.9	51.3	50.6	7.6	8.1	7.9	87.0	88.1	87.55 b	12.9	12.3	12.6
PAMG	50.7	47.0	48.9	7.1	7.8	7.5	94.7	99.6	97.15 a	11.3	13.2	12.3
Mean S	50.3	49.2		7.4	8.0		90.9	93.9		12.1	12.8	
MSD T 5%			NS			NS			2.76			NS
MSD S 5%			NS			NS			NS			NS

Treatment (T)	Storage root length (cm)			Storage root thickness (cm^2)			Storage root fresh weight (g)			Storage root dry weight (g)		
	1	2	Mean	1	2	Mean	1	2	Mean	1	2	Mean
Control	15.4	14.3	14.9	2.2	2.2	2.2	69.6	66.6	68.1 a	14.1	10.5	12.3
PAMG	14.5	13.5	14.0	2.2	2.4	2.3	59.3	65.3	62.3 b	13.0	14.1	13.6
Mean S	15.0	13.9		2.2	2.3		64.5	66.0		13.6	12.3	
MSD T 5%			NS			NS			3.53			NS
MSD S 5%			NS			NS			NS			NS

1 = first season 2 = second season

As shown from our results, using PAMG led to improve plant fresh weights compared with the control. These result may be due to the synergistic effect of PAMG and waste water on increasing the availability of nutrients, especially N via enhancing the activity of soil enzymes (urease and amidase), which involved in N cycling (Kay-Shoemake *et al* 2000). The enhancement of plant growth is due to the addition of PAMG, which can be attributed to its hydrophilic properties (increase water retention) and its role in improving the physical properties of the used sandy soil (Chatzoudis and Valkanas, 1995; Choudhary *et al* 1995; Salem *et al* 1995; Al-Harbi *et al* 1996; Al-Skeikh and Al-Darby, 1996; Al-Omran and Al-Harbi, 1998; Mostafa, 2002; Mansour, 2004).

Effect of soil treatments on heavy metals concentration

The data corresponding to the effects of soil treatments on heavy metals concentration of carrot roots are given in Tables (6-8).

The results concerning the effect of *Bacillus subtils* on heavy metals concentration of carrot roots are presented in Table (6). *Bacillus subtils* treatment was found to have significantly lower Mn, Ni, Pb and Cd concentrations than the control. But, it did not affect Fe and Cu in carrot roots. On the other hand, *Bacillus subtils* treatment led to significant increase in the content of Zn.

In Table (7), the effect of super phosphate calcium (SPC) on heavy metals concentration of carrot roots was observed in both seasons. Carrot roots contents of Fe, Cu, Mn, Ni and Pb were decreased significantly by the application of SPC_1 (250 Kg/fed) when compared to control.

However, rising super phosphate calcium rate from 250 to 500 kg/fed., significantly decreased Mn contents in plant root. On the other hand, Ni, Pb and Cd contents of carrot roots were higher than either control or SPC_1.Effect of SPC_2 in the same plant did not reach the level of significance with Zn and Cu contents when compared with the control.

The data involving the effects of PAMG treatment on heavy metals concentration in carrot roots (Table 8). Different trend was noticed in heavy metals concentration by PAMG treatment. There was great reduction in Mn content as compared to control by PAMG treatment in carrot roots. On the contrary, there were significant increments in Zn, Ni and Pb contents in carrot roots by adding PAMG. It is also noticed that Fe, Cu and Cd contents of carrot roots were not affected significantly via PAMG treatment.

Table 6. Effect of *Bacillus subtlis* (BS) on heavy metals concentration (ppm) in root of carrot plant irrigated with treated waste water in seasons 2003 and 2004 .

Treatment (T)	Fe			Zn			Cu			Mn		
	1	2	Mean	1	2	Mean	1	2	Mean	1	2	Mean
Control	147.5	161.0	154.3	58.3	46.6	52.45 b	8.9	10.1	9.5	21.0	22.5	21.75 a
BS	157.6	147.8	152.7	68.8	65.8	67.3 a	10.2	9.5	9.9	10.5	13.6	12.05 b
Mean S	152.6	154.4		63.6	56.2		9.6	9.8		15.8	18.1	
MSD T 5%			NS			1.34			NS			2.06
MSD S 5%			NS			NS			NS			NS

Treatment (T)	Ni			Pb			Cd		
	1	2	Mean	1	2	Mean	1	2	Mean
Control	9.2	10.3	9.8 a	15.5	15.8	15.7 a	0.8	1.4	1.1 a
BS	6.6	5.9	6.3 b	10.0	9.0	9.5 b	0.0	0.0	0.0 b
Mean S	7.9	8.1		12.8	12.4		0.4	0.7	
MSD T 5%			1.31			1.26			0.32
MSD S 5%			NS			NS			NS

1 = first season 2 = second season

Table 7. Effect of super phosphate calcium (SPC) on heavy metals concentration (ppm) in root of carrot plant irrigated with treated waste water in seasons 2003 and 2004 .

Treatment (T)	Fe			Zn			Cu			Mn		
	1	2	Mean	1	2	Mean	1	2	Mean	1	2	Mean
Control	147.5	161.0	154.3 a	58.3	46.6	52.5	8.9	10.1	9.5 a	21.0	22.5	21.8 a
SPC1	97.7	88.4	93.1 c	56.0	56.4	56.2	6.2	6.1	6.1 b	17.8	16.5	17.2 b
SPC2	120.5	131.4	126.0 b	53.8	57.9	55.9	9.0	9.5	9.25 c	15.3	14.5	14.9 c
Mean S	121.9	126.9		56.0	53.6		8.0	8.6		18.0	17.8	
MSD T 5%			9.43			NS			1.47			1.69
MSD S 5%			NS			NS			NS			NS

Treatment (T)	Ni			Pb			Cd		
	1	2	Mean	1	2	Mean	1	2	Mean
Control	9.2	10.3	9.8 b	15.5	15.8	15.7 b	0.8	1.4	1.1 b
SPC1	2.8	3.3	3.1 c	5.0	5.0	5.0 c	0.6	0.6	0.6 b
SPC2	15.7	16.0	15.9 a	22.8	24.3	23.6 a	3.3	4.6	4.0 a
Mean S	9.2	9.9		14.4	15.0		1.6	2.2	
MSD T 5%			1.46			1.52			1.03
MSD S 5%			NS			NS			NS

1 = first season 2 = second season
SPC1 = 250 Kg / fed SPC2 = 500 Kg / fed

Table 8. Effect of polyacrylamide hydrogel (PAMG) on heavy metals concentration (ppm) in root of carrot plant irrigated with treated waste water in seasons 2003 and 2004 .

Treatment (T)	Fe			Zn			Cu			Mn		
	1	2	Mean	1	2	Mean	1	2	Mean	1	2	Mean
Control	147.5	161.0	154.3	58.3	46.6	52.5 b	8.9	10.1	9.5	21.0	22.5	21.8 a
PAMG	158.5	151.4	155.0	75.2	72.5	73.9 a	10.3	9.8	10.1	15.7	15.9	15.8 b
Mean S	153.0	156.2		66.8	59.6		9.6	10.0		18.4	19.2	
MSD T 5%			NS			6.1			NS			1.39
MSD S 5%			NS			NS			NS			NS

Treatment (T)	Ni			Pb			Cd		
	1	2	Mean	1	2	Mean	1	2	Mean
Control	9.2	10.3	9.8 b	15.5	15.8	15.7 b	0.8	1.4	1.1
PAMG	11.5	14.0	12.8 a	25.0	25.0	25.0 a	1.9	1.8	1.9
Mean S	10.4	12.2		20.3	20.4		1.4	1.6	
MSD T 5%			1.79			1.15			NS
MSD S 5%			NS			NS			NS

1 = first season 2 = second season

Generally, it could be concluded that inoculation with *Bacillus subtils* decreased the hazard effect of heavy metals added to soil as a result of treated waste water. In case of lead uptake from the soil by plants, it is observed that, inoculation with *Rhizobium* decreased this uptake compared with uninoculated plants (El-Ghandour *et al* 1996). Microbial cells as biosurfactants and bioremediation are used to concentrate and/or precipitate metals for their removal (Kosaric, 2001). Many microbial species such as bacteria, yeast and algae are known to be capable of adsorbing heavy metals on their surface and/or accumulating within their structure (Campbell and Martin, 1990; Vinita and Radhanath, 1992; Ilhan *et al* 2004). In the other hand, Zn content increased in carrot roots. The increase of this element in carrot roots can be related to its increase in the soil, as a result of treated waste water (Sherif *et al* 2000). This increase may be attributed to decomposition of organic amendments and formation of metal-humates and metal fulvates (Khalifa and Hassan, 1993). Arnesen and Singh (1998) indicated that some of the metals bound by organic matter were probably released as the organic matter was decomposed.

Statistically, significant and negative effect of Fe, Cu, Mn, Ni and Pb contents was noticed in carrot roots by SPC_1 treatment. While its effect on Cd and Zn was mostly insignificant. In this regard Marr *et al* (1999) mentioned that available PO_4 may reduce uptake of Cu and Zn. These results indicate a clear relationship between the concentration of available soil P and the concentration of Cu or Zn in the tissues. Pierzynski and Schwab (1993) reported that P encourages plant growth, which results in the concentration of Zn being diluted within the plant as well as an inhibition of the translocation of Zn from the roots to the tops. Luo and Rimmer (1995) suggested that Cu and Zn behave in a similar fashion. It is also possible that the P absorbed or precipitated the metals to from insoluble complexes and therefore makes both the metals and the P unavailable to plants (Ross, 1994).

Different mechanisms could enable plants to tolerate elevated concentrations of metals in the soil (Baker, 1981). One is called "excluder" mechanism whereby the plant blocks the translocation of metals from the root in order to reduce the accumulation in the leaves. Another physiological mechanism is saturation of the system, which is responsible for transporting metals into the root.

The cadmium (Cd) concentration in the plant was increased. As the decrease in soil pH due to sludge, it is believed that pH effect increased Cd uptake. Soon *et al* (1980) reported that the effect of pH on Cd uptake was greater than on Zn uptake. Ni concentration was increased. Similar results were obtained with Zwarich and Mills (1982) who stated that the concentration of Ni was increased in carrot roots as a result of sludge application; Koriem (1993) confirmed these results.

Generally, the highest significant content of Zn and Pb in carrot roots was obtained by PAMG treatment. The previous results may be due to decrease soil pH and increase organic matter as a soil conditioner.

The effect of organic matter application on the solubility of heavy metals in the soil and plant uptake depended on the source of organic matter, the metals studied and the time after its application (Arnesen and Singh, 1998). Besides, PAMG enhancing the physic-chemical properties of sand and eventually increased the uptake of nutrients (Bowman *et al* 1990), leading to more accumulation of dry matter of leaves. Also, PAMG may act on chelating some heavy metals, thus their precipitating effect on P would be reduced. Besides, PAMG may accelerate the decomposition of sewage sludge compost (Barvenik, 1994) and keeps it in the medium bulk (Lentz *et al* 2001).

The results are quite similar to those obtained by De Pieri *et al* (1997) who found that leaf Cd and Pb concentrations were generally much greater than that in the root. No clear relationship was observed between total soil and plant tissue concentration for Cd or Pb. Cadmium was more variable in the plant tissues than Pb, particularly in the leaves.

Effect of soil treatments on nitrate and nitrite concentration

Effect of soil treatments on nitrate and nitrite concentration in carrot roots are presented in Tables (9 – 11). *Bacillus subtils* treatment (Table 9) led to significant decrease in NO_3^- and NO_2^- concentration. Nitrate concentration (Table 10) was significantly decreased in response to SPC treatment. On the contrary, statistical analysis indicates a significant increase of NO_2^- concentration due to SPC treatment over the control. Table (11) shows the NO_3^- and NO_2^- concentrations in carrot roots affected by PAMG treatment. The results indicated that the NO_3^- and NO_2^- concentrations in carrot roots increased with PAMG treatment which recorded the highest significant NO_3^- and NO_2^- concentration. While the lowest one was detected by *Bacillus subtils* treatment in carrot roots.

The high concentrations of NO_3^- may be attributed to the high content of total N due to the irrigation with waste water (sewage effluent), where NO_3^- is considered a storage for N in the plant and dose not usually accumulate unless total N levels is high (Bartholomew and Clark, 1965; El-Sayed, 1998; Abd Alla and Mohamad, 2004).

The low concentrations of NO_2^- may be due to the high amount of NO_3^-, this result agrees with Bartholomew and Clark (1965) who observed that nitrate concurrently in the solution diminished NO_2^--toxicity. Khatab (2001) recorded similar trend of NO_2^-. In addition, close relationships in removal capacity by bacterial cells were obtained between the uptake of cobalt with nitrite, nitrate and cadmium (Kosba and Zaied, 1997).

Table 9. Effect of *Bacillus subtils* (BS) on nitrate and nitrite concentration (ppm) in root of carrot plant irrigated with treated waste water in seasons 2003 and 2004 .

Treatment (T)	Nitrate (ppm)			Nitrite (ppm)		
	1	2	Mean	1	2	Mean
Control	300	375	337.5 a	0.70	0.82	0.76 a
BS	250	220	235.0 b	0.59	0.50	0.55 b
Mean S	275	297.5		0.65	0.66	
MSD T 5%			41.26			0.14
MSD S 5%			NS			NS

Table 10. Effect of super phosphate calcium (SPC) on nitrate and nitrite concentration (ppm) in root of carrot plant irrigated with treated waste water in seasons 2003 and 2004 .

Treatment (T)	Nitrate (ppm)			Nitrite (ppm)		
	1	2	Mean	1	2	Mean
Control	300	375	337.5 a	0.70	0.82	0.76 b
SPC1	290	275	282.5 b	1.30	1.30	1.30 a
SPC2	340	275	307.5 ab	1.00	1.60	1.30 a
Mean S	310	308.3		1.00	1.23	
MSD T 5%			48.77			0.31
MSD S 5%			NS			NS

Table (11). Effect of polyacrylamide hydrogel (PAMG) on nitrate and nitrite concentration (ppm) in root of carrot plant irrigated with treated waste water in seasons 2003 and 2004 .

Treatment (T)	Nitrate (ppm)			Nitrite (ppm)		
	1	2	Mean	1	2	Mean
Control	300	375	337.5 b	0.70	0.82	0.76 b
PAMG	430	450	440.0 a	1.50	1.55	1.53 a
Mean S	365	412.5		1.10	1.18	
MSD T 5%			39.73			0.12
MSD S 5%			NS			NS

Generally, PAMG treatment led to significant increase in NO_3^- and NO_2^- concentrations. These results may be attributed to the synergistic effect of PAMG and waste water on increasing the availability of nutrients especially N. The efficiency of PAMG serves as a nitrogen source (Barvenik, 1994). Also, Kay-Shoemake *et al* (2000) stated that PAMG contains amide-N. The nitrification rate of urea and encapsulated urea-derived NH_4^+-N was slightly accelerated in the PAMG treated soil.

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تأثير بعض معاملات التربة المقللة للأيونات الضارة علي نبات الجزر المروي بماء الصرف الصحي المعالج

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الملخص العربي

أجريت تجربتين حقليتين فى 15 سبتمبر عامى 2003 & 2004 على تربة رملية بكر فى المزرعة التجريبية بالجبل الأصفر بمحافظة القليوبية بهدف تقليل الأثر الخطير لبعض الايونات الضارة نتيجة للرى بماء الصرف الصحى المعالج لنبات الجزر، وذلك باستخدم عدد من معاملات التربة تتضمن بكتيريا باسيلس ساتلس وسوبر فوسفات كالسيوم (بمعدلين 250 & 500 كجم/فدان) والبولي اكريلاميدهيدروجيل. وقد أخذت عينات من النباتات لدراسة خصائص النمو وبعض التقديرات الكيماوية بعد 90 يوما من الزراعة (عند الحصاد).

أظهرت النتائج زيادة معنوية ملحوظة في الوزن الطازج للنبات نتيجة للتلقيح مع بكتيريا باسيلس ساتلس ومعاملة سوبر فوسفات كالسيوم (بمعدل 250 كجم/فدان) وبولي اكريلاميدهيدروجيل مقارنة بالكنترول. كما أحرزت معاملات بكتيريا باسيلس ساتلس والبولي اكريلاميدهيدروجيل زيادة ونقص معنوي في الوزن الطازج للجذر الخازن على الترتيب.

أوجدت معاملة بكتيريا باسيلس ساتلس انخفاضاً معنوياً في محتوى المنجنيز والنيكل والرصاص والكادميوم وارتفاع في محتوى الزنك. أدت معاملة سوبر فوسفات كالسيوم (بمعدل 250 كجم/فدان) لنقص معنوى في محتوى الحديد والنحاس والمنجنيز والنيكل والرصاص. كما أظهرت معاملة سوبر فوسفات كالسيوم (بمعدل 500 كجم/فدان) نقص معنوى في محتوى الحديد والمنجنيز وزيادة في محتوى النيكل والرصاص والكادميوم عن الكنترول. أعطت معاملة البولي اكريلاميدهيدروجيل نقصاً معنوياً في محتوى المنجنيز وزيادة في محتوى الزنك والنيكل والرصاص. أعطت معاملة بكتيريا باسيلس ساتلس أعلى تركيز للنترات والنتريت بينما أعطت معاملة البولي اكريلاميدهيدروجيل أقل تركيز لهذين الأيونين.