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USING CANOLA PLANTS FOR PHYTOEXTRACTING HEAVY METALS FROM SOILS IRRIGATED WITH POLLUTED DRAINAGE WATER FOR A LONG TERM

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ABSTRACT

Canola *Brassica napus* Seru-4 variety was grown in lyzimeter experiment at Sakha Agric. Res. Station during 2008/2009 season to study the metal accumulation and it's feasibility of it's use for metal phytoextraction. Also, chosen to study the content of roots, stems, leaves, seeds and oils of heavy metals Mn, Cu, Zn, Ni, Cd and Pb as affected by water treatments Lyzimeters (100 x 70 x 90 cm) were field with clayey soil and irrigated with three water treatments since 1987 twenty years ago. They were W_1, Nile water (good water quality) and W_3, drainage water (relatively poor water quality) and W_2, mixed water 50% W_1 + 50% W_3. Complete randomized block design with four replicates was used for statistical analysis.

The obtained results showed that:

- Using poor water quality for irrigation increased ECe, SAR, soluble cations and anions in soil paste extract and total DTPA extractable heavy metals in soils (Mn, Zn, Cu, Ni, Cd and Pb) than that of mixed or good water quality.
- No significant effect of water treatment was found on plumule length swelling coefficient, hydration coefficient, crude fat, ash, relative density percent of canola seeds.
- The best main radical length and crude protein were obtained in seeds of canola plants irrigated with drainage water.
- Content of the studied heavy metals were in the following order: roots > stems > leaves > seeds > oils and greater when poor water quality (W_3) was used for irrigation water.
- Highly significant differences were found between means of heavy metal content in canola plant due to irrigation water treatment.
- Canola oils which extracted from seeds were the least content of studied heavy metals in canola plant organs.
- Canola behaved as an accumulator for heavy metals such as Zn, Mn, Cd, Ni and Pb and is useful for metal phytoextraction due to higher metal accumulation capacity.

Keywords: Phytoremediation, remediation, heavy metals, polluted soils, canola phytoextraction.

INTRODUCTION

Heavy metal pollution is a convenient term for accumulation in the soils in its common forms of combination heavy metals are potentially toxic to plants or may be taken up by plants in sufficient amount to be harmful to the animals that eat them. A recent study showed a remarkable increase in levels of heavy metals in some Egyptian soils (especially soils lies in the extreme North Delta) in addition appreciable amount of these metals are found in vegetation, water bodies and aquatic organisms in western and Middle areas of the Nile Delta (El-Sanafawy, 2002 and Zein *et al.*, 1998).

Use of low quality water in irrigation could be an important consideration when the disposal is being planned in arid and semi arid regions. Using drainage water in irrigation caused high increase in the EC and SAR of the saturated soil paste extract (Omer *et al.*, 2001) meanwhile, using drainage water in irrigation significantly increase the total and DTPA extractable heavy metals compared with Nile water (Zein *et al.*, 2002).

Technologist to minimize the chance of heavy metals reaching food chaine are primarily aimed at reducing its uptake by plants and animals. It has often been observed that the bioavailability of metals decrease with increasing time after their introduction to soils (i.e. aging) (Bolan *et al.*, 2003). However, some of the fractions of the accumulated metals are likely to be soublilized in water contain environmental conditions and become mobilized for plant uptakes and leaching to ground water (Martinez *et al.*, 2003). Salt *et al.*, (1998) stated that phytoremediation can be as the combined use of plants, soil amendments and agronomic practices to remove pollutants from the environment or to decrease their toxicity.

Phytoextraction techniques involve the elimination of pollutants from the soil, the toxic elements accumulating in the harvestable parts of the plants (McGrath, 1988; Ebbs and Kochian, 1997 and Rafel Clemente *et al.* 2005).

Canola is a plant species known to accumulate Zn and especially Pb (Ebbs and Kochian, 1997; Epstein *et al.*, 1999 and Schulman *et al.*, 1999) which can be adapted to Mediterranean climates (Del Rio *et al.*, 2000 and Veerle *et al.*, 2006).

The objectives of the present work are to assess the effect of different irrigation water sources on canola crop, physical properties and chemical composition of seeds and their elemental content of heavy metals. The feasibility of its use for heavy metal accumulation phytoextraction and their relationships with soil condition and bioavailable concentration.

MATERIALS AND METHODS

Lyzimeter experiment was conducted at Sakha Agricultural Research Station during the winter season of 2008/2009. The investigation aimed to study the effect of the irrigation water qualities: (W_1) Nile water (good quality), (W_2) mixed water (50% Nile water + 50% drainage water) and (W_3) drainage water (poor quality) on the yield and the content of some heavy metals of canola plant. The trials were carried in above ground cement lyzimeters established and irrigated with three water treatments since 1987 (100 x 70 x 90 cm). The soil is clay in texture (typic ustorthent); 58% clay, 16% silt and 26% sand. The experimental statistical design was a complete randomized with four replicates.

The seeds were sown on 19th of September 2008, the experiment was treated with 15 kg P_2O_5/fed (super phosphate, 15.5% P_2O_5) added before sowing and nitrogen fertilizers at the rate of 70 kg/fed (ammonium sulphate 20% N) was splitted in two equal doses. The first does was added after thinning and the second dose was added after 30 day from thinning with the third irrigation. The K fertilizer at the rate of 48.0 kg K_2O/fed (K_2SO_4; 48% K_2O) was applied with the 1st dose of nitrogen. Plants were thinned to one plant per/hill after 50 days form sowing, canola was harvested on 1st April of 2009 season.

Representative samples of canola roots were taken at the same time of harvesting from each lyzimeter for analysis, dry ashing technique was used for samples digestion (Chapman and Pratt, 1961) and analysed for Mn, Zn, Cu, Ni, Cd, and Pb using Atomic Absorption method (Perkin-Elmer 3300). Soil samples were taken before planting from each lyzimeter for chemical analysis, ECe and soluble cation anions in the soil paste extract,(Richards, 1969).

Some chemical soil properties are presented in Table (2). Soil samples were analyzed for Mn, Zn, Ni, Cd and Pb by the atomic absorption spectrophotometer, Perkinelmer 3300 (Lindsay and Norval, 1978)

The resulted canola seeds from plants irrigated with different types of water was subjected to physical, chemical analysis, and viability testes.

Germination test was carried out under optimum conditions according to international rules (ISTA, 1993). The radical shoot length and seedling dry weight were measured according to the procedures exported in the seed vigar testes hand book (A.O.S.A., 1991).

The relative density was calculated according to the method described by Kramer and Twigg, 1962.

The hydration coefficient was calculated according to Hulse *et al.* (1977). The swelling coefficient was calculated according to Ziena (1989).

For chemical analysis samples of seeds were ground to fine powder to pass through 2 mm sieve. Dry weight, crude protein, fat content and ash were determined according to the procedures outlined in AOSA, 1991.

The present work presents the results of the experiment concerning growth and heavy metal accumulation and uptake of canola and their relationship with the soil condition and bioavailable concentration of metals.

Statistical analysis was carried out using IRRISTAT soft ware, Version (3) 1993 (Biometric Unit, International Rice Research Institute, Philippine).

RESULTS AND DISCUSSION

Nile and drainage waters evaluation:

Chemical characteristics of Nile and drainage waters used for irrigation of canola plant are shown in Table (1). According to Richard's classification, Nile water C_2S_1; medium salinity low sodicity (Richards, 1969). While, data of drainage water revealed that is (C_4S_2); high salinity and sodicity which can not be used on soils with restricted drainage and crop with good salt tolerance should be selected. It can be concluded that Nile water is of good quality and drainage water of poor quality for irrigation. The mixed water will be intermediate between them in relation to its chemical composition.

Table (1): Chemical characteristics of Nile and waste water in 19th Sept. of 2008 to first April, 2009.

Irrigation water	EC dS/m at 25°C	pH	Anions meq/L				Cations meq/L				SAR	Water class
			CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}		
Nile	0.30	7.25	-	3.09	0.75	0.36	1.70	0.97	1.30	0.23	1.13	C_2S_1
Waste	2.30	8.40	-	4.05	18.0	3.47	4.30	4.35	16.40	0.47	7.89	C_4S_2

	Heavy metals content (ppm) in irrigation water					
	Mn	Cu	Zn	Ni	Cd	Pb
Nile water	0.015	0.015	0.056	0.0070	0.005	0.075
Drainage water	0.369	0.163	0.396	0.602	0.035	0.665
Critical limits according FAO (1989)	0.200	0.200	2.00	0.200	0.010	5.00

Effect of studied irrigation water qualities on some chemical properties of clay soil:

Table (2) revealed that ECe values of the studied soils after harvesting increase from 5.0 to 5.10, 5.60 to 5.68 and 6.30 to 7.32 dS/m due to W_1, W_2 and W_3 water treatments.

Table (2): Effect of irrigation water on chemical analysis of soil paste extract before planting and after harvesting.

Water treatment	Anions (meq/L)				Cations (meq/L)				Soil pH	ECe dS/m	SAR
	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}			
	Before planting										
Nile water (W_1)	-	2.80	10.80	27.90	21.20	10.4	19.80	0.30	8.30	5.00	5.00
Mixed water (W_2)	-	2.60	17.00	38.90	22.60	11.20	24.30	0.40	8.20	5.60	6.00
Waste water (W_3	-	2.60	24.60	34.80	23.80	11.90	29.0	0.40	8.10	6.30	6.90
	After planting										
Nile water (W_1)	-	3.19	11.91	36.87	22.0	11.11	19.11	0.39	8.00	5.10	5.52
Mixed water (W_2)	-	2.91	27.36	52.37	31.25	12.58	38.35	0.46	8.10	5.68	8.19
Waste water (W_3	-	2.81	41.21	59.14	35.21	17.12	49.98	0.55	8.20	7.32	9.74

Effect of irrigation water qualities on canola seed and straw yields (ton/fed):

Data in Table (3) show that maximum values were 3.705, 2.194 and 1.511 (ton/fed) for biological, straw and seed yields, at W_2, respectively. While, the corresponding minimum values were 3.023, 1.798 and 1.226 (ton/fed), at W_3. This may be due to drainage water contain materials and some leached fertilizers, which enhanced plant growth whereas it contain some salts which have hazardous effects. This conclusion is in partial agreement with that of Shalaby *et al.*, 1996 and Zein *et al.*, 2002, who concluded that the increasing of heavy metal concentration in plant may be attributed either to the higher amount of these heavy metal added into the used soil throughout the applied wastes or to the opposite of the dilution effect phenomenon in one hand and to salt affect on the other hand.

Table (3): Effect of water treatments on the biological seed and straw yields (ton/fed) of canola plant.

Water treatment	Biological yield (ton/fed)	Straw yield (ton/fed)	Seed yield (ton/fed)
W_1	3.290 b	1.830 b	1.461 a
W_2	3.705 a	2.194 a	1.511 a
W_3	3.023 c	1.798 b	1.226 b
L.S.D.$_{0.05}$	0.146	0.151	0.053
L.S.D.$_{0.01}$	0.221	0.228	0.081

Data presented in Table (4) indicate that the type of water treatment had significant effect on germination, radical length and seedling dry weight whereas the type of irrigation water has no significant effect on plumule length, relative density, swelling and dehydration coefficients. The best germination and seedling dry weight of the resulted seeds were obtained from Nile water treatment, while seeds from plants irrigated with drainage water have the least germination. On the contrary, the best radical length was obtained in seeds of plants irrigated with drainage water.

Table (4): Effect of water treatment on physical properties of canola seeds.

Treatment	Germination %	Radical length cm	Plumule length (cm)	Seedling dry weight (gm)	Relative density	Swelling coefficient	Hydration coefficient
W_1	92.667 a	6.87 b	9.617 a	0.0087 a	0.147 a	1.642 a	161.88 a
W_2	85.992 b	6.743 b	10.057 a	0.0050 b	0.141 a	2.067 a	148.057 a
W_3	69.267 b	7.262 a	9.587 a	0.006 ab	0.143 a	2.650 a	169.167 a

The chemical composition of obtained seeds was shown in Table (5). Crude protein was significantly higher in seeds from plants irrigated related with drainage water probability because drainage water has higher nitrogen content or/and the drainage water causes low dry seeds weight% which led to high crude protein%. The type of water treatment had no significant effects on crude fat, ash and dry weight percent.

Table (5): Effect of irrigation water quality on chemical composition of canola seeds.

Treatment	Crude % protein	Crude fat %	Ash %	Dry weight %
W_1	34.377 b	34.66 a	5.178 a	89.837 a
W_2	41.44 a	34.247 a	5.301 a	89.200 a
W_3	41.48 a	34.758 a	5.387 a	89.263 a

Heavy metals accumulation in canola:

The concentration of studied heavy metals in the canola tissues Table (6) and Fig. (1) increased in the order: oils < seeds < leaves < stems, < roots under all water types (Nile, mixed and drainage). Mn, Zn, Cu, Ni, Cd and Pb were found in higher concentration in roots, stems and leaves especially Zn, Cu, Ni and Pb in most tissues exceeded the levels found in canola plant grown in non contaminated soil (37.5, 0.07 and 14.9 μg/g^{-1}) for Zn, Pb and Cu according to del Rio *et al.* (2000). Lead concentrations were above the normal concentration (10 μg g^{-1}) (Kabata-Penedias 2001) in most parts of the plant. The concentration of Cd in plant tissues was very small although root concentration of up to 1.05 ppm. Also, Ni concentration in plant tissues was higher in leaves, stems and roots. The least concentration of the all studied heavy metals was found in oils.

Table (6): Effect of water quality on the heavy metals in canola plants (roots, stems, leaves, seeds and oils) and their translocation coefficient (Tc).

Water quality	Mn	Zn	Cu	Ni	Cd	Pb
	Roots					
W_1	31.823 c	3.698 c	14.800 c	4.050 c	0.197 c	50.545 c
W_2	76.195 b	5.510 b	24.160 b	12.483 b	0.243 b	96.977 b
W_3	91.467 a	7.258 a	33.653 a	19.015 a	1.018 a	116.050 a
	Stems					
W_1	16.293 c	2.798 e	4.265 a	2.743 c	0.120 b	25.170 c
W_2	27.750 b	3.898 b	3.903 a	6.188 b	0.143 b	36.168 b
W_3	56.660 a	5.913 a	4.568 a	9.048 a	0.238 a	44.168 a
	Leaves					
W_1	8.865 c	3.018 c	5.550 b	1.248 c	0.041 c	12.66 b
W_2	11.543 b	4.555 b	5.808 ab	3.175 b	0.117 b	14.91 b
W_3	20.975 a	6.360 a	5.960 a	6.205 a	0.189 a	20.73 a
	Seeds					
W_1	3.698 c	1.408 c	1.068 c	1.423 c	0.010 c	2.493 c
W_2	5.188 b	1.780 b	1.973 b	2.633 b	0.029 b	2.833 b
W_3	5.798 a	2.000 a	2.108 a	3.960 a	0.086 a	2.943 a
	Oils					
W_1	1.16	1.01	0.15	0.98	0.0010	1.07
W_2	1.22	1.30	0.58	1.00	0.0023	2.00
W_3	1.99	1.55	0.96	1.02	0.0041	2.76
	Translocation coefficient (%) from straw to seeds					
W_1	49.50	24.03	24.44	55.25	8.18	10.39
W_2	48.40	20.12	47.64	45.13	21.43	8.26
W_3	36.83	11.24	48.17	45.89	34.67	6.29
	Translocation coefficient % from roots to straw					
W_1	48.31	76.43	29.58	63.46	55.84	47.42
W_2	33.86	72.20	17.12	46.70	57.61	35.34
W_3	56.42	82.27	13.02	45.37	22.84	40.30

*** The data of oil was unique compost sample.**

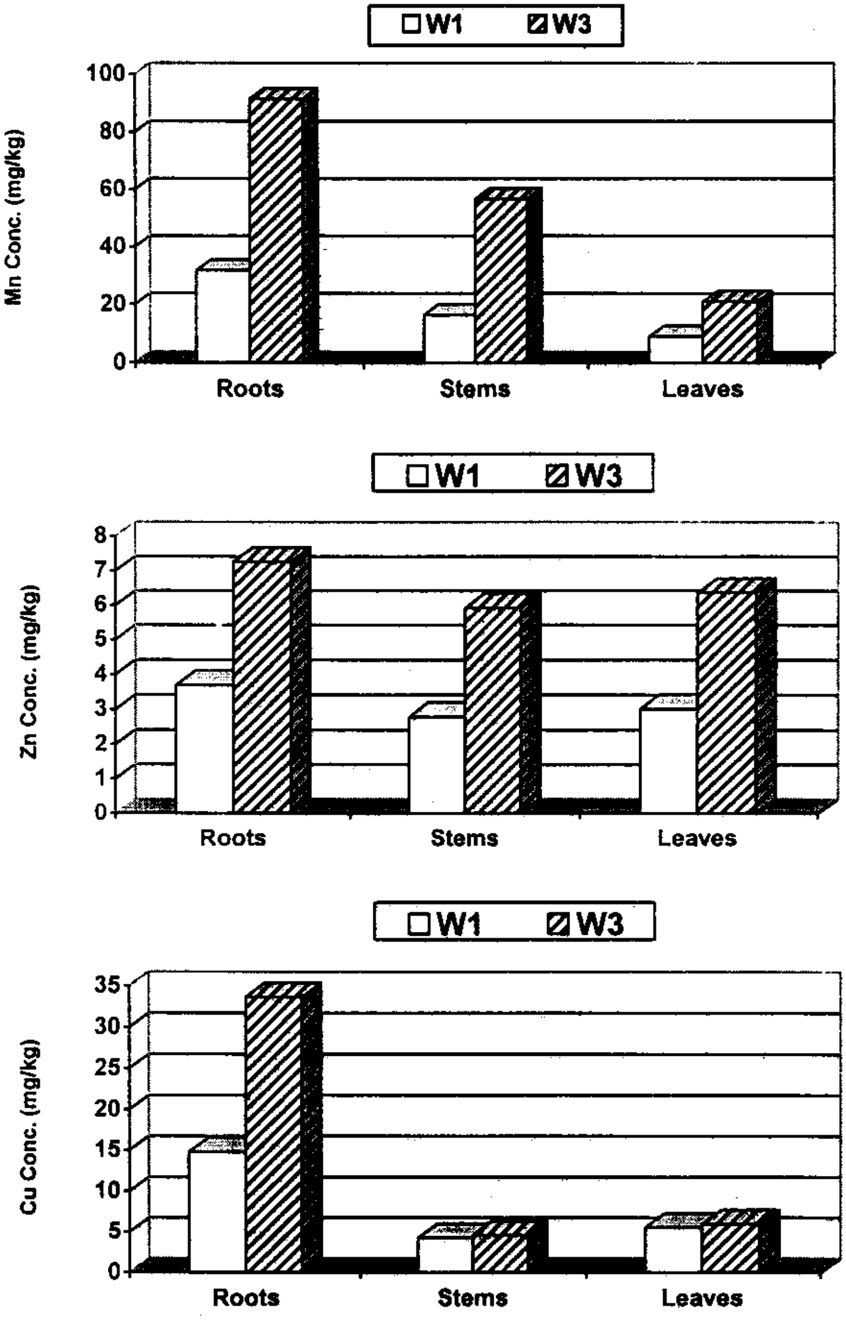

Fig. (1): Effect of W1 and W3 treatment on heavy metals concentration of roots, stems and leaves.

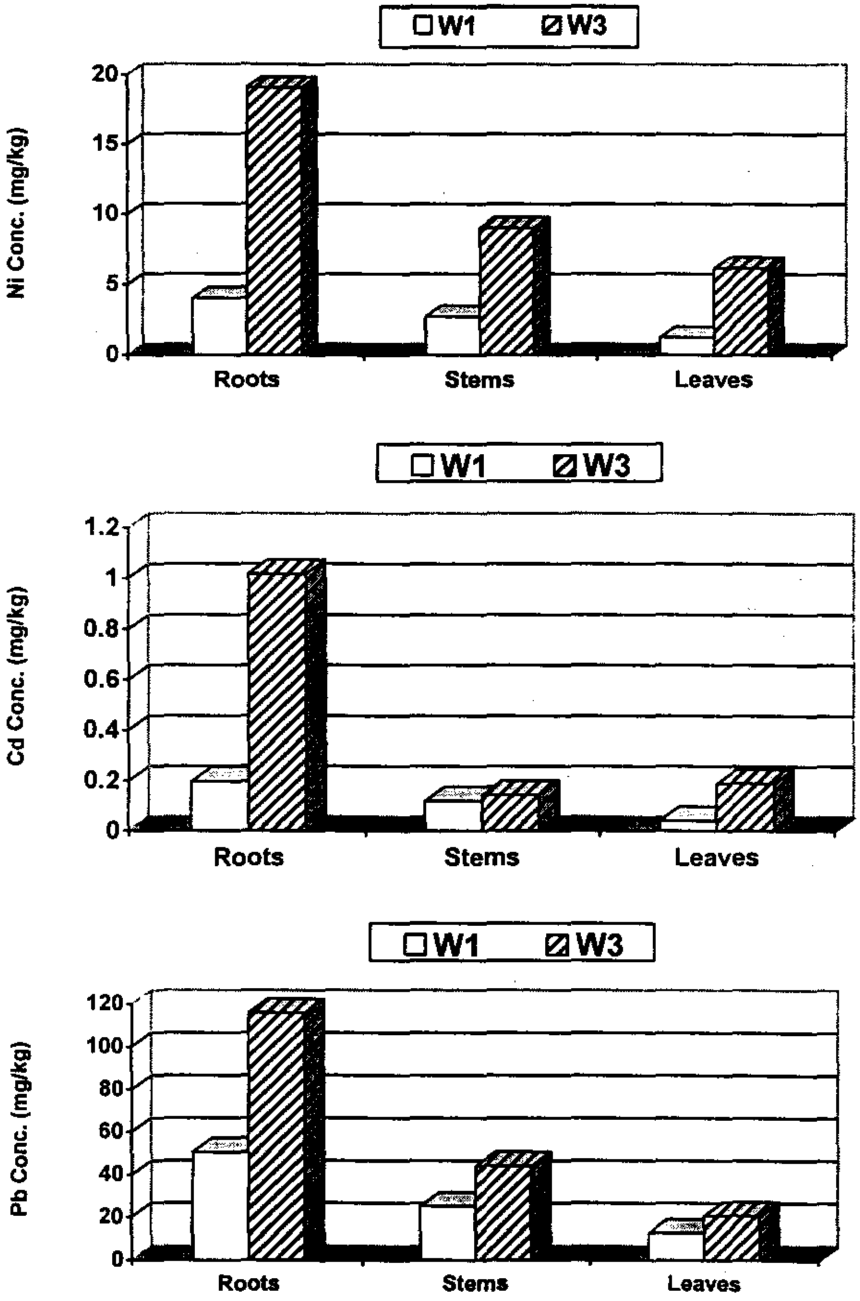
□W1 ▨W3
Ni Conc. (mg/kg)
0
5
10
15
20
Roots
Stems
Leaves
□W1 ▨W3
Cd Conc. (mg/kg)
0
0.2
0.4
0.6
0.8
1
1.2
Roots
Stems
Leaves
□W1 ▨W3
Pb Conc. (mg/kg)
0
20
40
60
80
100
120
Roots
Stems
Leaves

Fig. (1): Cont..

Data in Table (6) showed that the studied heavy metals Cd, Pb, Ni, Mn, Zn and Cu content of canola plant under drainage water were greatest than that of Nile water and mixed water. This could be attributed to the pollution sources of industrial (oil and soap factory) and municipal wastes discharged to the drainage system. These results are in agreement with those obtained by Zein *et al.* (2002) and El-Mowelhi *et al.* (1995).

Data in the same Table and Fig. (1) illustrate the influence of water quality on the studied heavy metals (means) concentration in roots, stems, leaves, seeds and oils on canola plant especially which irrigated by drainage water (W_3) were as the following order:

Roots : Pb > Mn > Cu > Ni > Zn > Cd.
Stems : Mn > Pb > Ni > Zn > Cu > Cd.
Leaves : Mn > Pb > Zn > Ni > Cu > Cd.
Seeds : Mn > Pb > Ni > Zn > Cu > Cd.
Oil : Pb > Mn > Zn > Ni > Cu > Cd.

While, the main concentration of Pb in plant tissues of canola irrigated with drainage water were 116.05, 44.17, 20.73, 2.94 and 1.94 ppm (root, stems, leaves, seeds and oils, respectively). Zein *et al.,* 2007 found that the main sources of Pb in water, soil and plants are mainly related to the waste water of some factories as oil and soap factories. They also added that the most amount of Pb was associate with the soluble, exchangeable, carbonate specifically and hydroxides fractions. In the present study the input of Pb with drainage water, which polluted from oil & soap wastes of Katr El-Sheikh, absorbed by plant tissues from the drainage water.

Statistical analysis Table (6) revealed that highly significant effect of water quality (W_1, W_2 and W_3) on each of all studied heavy metals concentration in canola, but this effect was insignificant on Cu and Cd in stems.

Data in the same Table generally, reveal that the effect of water quality on heavy metals concentration in canola plant was highly significant with Mn, Zn, Ni and Cd but the effect for Pb and Cu in leaves was significantly effect of W_3 on each of W_1 and W_2 and insignificant between W_1 and W_2 means. Data of Cu concentration in leaves show that their was significant differences between W_3 treatment mean and each of W_1 and W_2 treatment.

The above discussion indicate that their were significant influence of water type on the content of heavy metals in such plants. Zein *et al.,* 2002 found the same results in wheat cultivars.

Suitability of canola for phytoextraction:

Data in Table (7) show that all values of the total and DTPA extractable heavy metals of soils can be discendingly according to the effect of treatments as follows: $W_3 > W_2 > W_1$ before canola planting and after harvesting. Also, the values of total increased but DTPA extractable values were nearly the same before planting and after harvesting canola plant: This may be due to the phytoextraction effect of canola plant for clean up of contaminated as shown in the total uptake of heavy metals in the all part of canola plants in drainage water (W_3) in roots, stems.

Data of studied heavy metals concentration Table (6) and Fig. (1) indicate that using drainage water W_3 for irrigation increased Mn & Zn & Ni and Cd content up to 2.87, 3.48 and 2.36 times & 1.96, 2.11 and 2.11 times & 4.70, 3.30 and 4.97 times 5.17, 1.98 an 4.61 times of that W_1 treatment for roots, stems and leaves, respectively.

Table (7): Total and DTPA extractable heavy metal concentrations in soil from 2008 to 2009 (mg/kg) before planting and after harvesting canola plant.

Water irrigation quality	Heavy metal concentration (mg/kg)					
	Total			DTPA		
	(2008) before canola planting					
	Cd	Ni	Pb	Cd	Ni	Pb
W_1	0.1053	3.02	6.50	0.0991	1.71	3.97
W_2	0.1660	8.11	32i.2	0.1312	1.99	8.55
W_3	0.3303	10.06	70.11	0.1520	2.33	10.99
	(2009) after harvesting canola plants					
W_1	0.1500	3.06	6.59	0.0980	1.77	3.61
W_2	0.1879	8.22	38.12	0.1370	2.00	8.99
W_3	0.4001	11.99	79.55	0.1531	2.36	11.01

The bioavilability of metals decrease with increasing time of their introduction to soils (i.e. aging) (Bolan *et al.*, 2003). However, some of the fractions of the accumulated metals are likely to be solubilized under certain environmental conditions and become mobilized for plant uptake and leaching to ground water (Martinez *et al.*, 2003).

Once the ions have been absorbed through the roots and have been transported to the xyleme vessels, there is possibility of movement through the whole plant, the rate and extent of movement with plants depend on the metal concerned, the plant organ and the age of plant (Alloway, 1995).

The data of heavy metal concentration in seeds, straw, roots of studied canola plant and coefficient of their translocation (Tc) from roots to straw

$$\text{straw Tc} = \frac{\text{Content of heavy metal in straw (mg/kg)}}{\text{Content of the same heavy metal in roots (mg/kg)}} \times 100 \text{ are}$$

present in Table (6) and illustrate that the studied heavy metals translocation from straw to seed can be arranged according to mean values of translocation coefficient in the following decreasing order:

Translocation coefficient from straw to seeds	Translocation coefficient from roots to straw
W_1 Ni > Zn > Mn = Cu > Pb > Cd	Zn > Ni > Cd > Mn > Pb > Cu
W_2 Zn > Cu > Ni > Cd = Mn > Pb	Zn > Cd > Ni > Pb > Mn > Cu
W_3: Cu > Ni > Zn > Cd > Mn > Pb.	Zn > Mn > Ni > Pb > Cd > Cu

Data of translocation coefficient from roots to straw were calculated as TC of straw to seeds. It shows that Zn was the largest values of TC while Cu was the least in translocation from root to straws in all types of water treatments

(W_1, W_2 and W_3). The manner TC of an element calculating using the same formula.

Data of translocation coefficient from straw to seeds in the same Table show that Pb was the least. The results are in good agreement with the found by Zein *et al.*, 2002. They added that, under conditions of optimal growth, Pb precipitates on root cell wall in the insoluble amorphous form. Zhen-Guo Shen *et al.*, 2009 found that application of EDTA (as an organic conditioner) to the soil significantly increased the concentrations of Pb in the shoots and roots of all plants and was the best in solubilizing soil-bound Pb and enhancing Pb accumulation in the plants. They also added that the results of the sequential chemical extraction of soil samples showed that the Pb concentration in the carbonate-specifically adsorbed and Fe-Mn oxide phases were significantly decreased after EDTA treatment and solubilized mainly from these two phases in the soil.

Eissa and El-Kassas (1999) found that the concentration of Cu, Zn, Mn, Pb, Cd and Ni in roots were always higher than those of shoots or fruits. They concluded that this may indicate the immobility of these elements.

Data in Table (6) showed that Zn values are greater than that of Cu and this is in agreement with that of Kabata Pendias and Pendias (1992) who found that, following root absorption, the extent to which elements are translocated decreased in the following order Cd > Zn > Cu > Pb.

Table (6) reveal that Mn content in roots, stems and leaves were higher when irrigated with polluted drainage water 28.17 than that irrigated with mixed water and that irrigated with Nile water. Eid and Shereif (1996) revealed that Mn contents in plants were significantly affected by irrigation water and crop types.

The distribution of Cu within plants is highly variable within roots Cu is associated mainly with cell wall and its largely mobile. The highest concentration of Cu in shoots are always phase of intensive growth and at the "Luxury" supply level. Loneragan (1981) and Scheffer *et al.* (1979) showed that distribution of Cu in barley leaves is relatively uniform for a given stage of plant growth.

Data of Ni concentration in seed, straw yields (ppm) and translocation coefficient indicate that Ni values increased due to drainage water treatment than the other two treatments, this is due to its higher content of polluted drainage water from oil and soap factory (used Ni catalyst in one processes of manufacturing). Translocation coefficient values were 55.25, 45.13 and 45.89% at W_1, W_2 and W_3, respectively. This is found to be in good agreement with (Zein *et al.*, 2002) and Chancy and Giordano (1977) for heavy metals translocation.

Environmental Ni pollution greatly influenced the concentration of this metal in plants. In the ecosystems where, Ni is an air borne pollutant, the tops of plants are likely to concentrate the most Ni, which can be washed from the leaf surfaces quite easily (Ashton, 1972). As Ni is easily mobile in plant, berries and seeds are reported to contain elevated Ni concentration (Alina and Pendias *et al.*, 2000).

Cadmium value (Table 6) of seeds and oils content indicated that Cd has the lowest values in all studied heavy metals which were 0.010, 0.029 and 0.086 ppm for seeds and 0.0010, 0.0023 and 0.0041 ppm for oils at W_1, W_2 and W_3 water treatment, respectively. This conclusion are in agreement with Alloway (1995) who found that the uptake of Cd decreased when pH was increased, canola showed a similar response. Page *et al.* (1981) found that relative excess of Cu, Ni and Mn can reduce uptake of Cd by plants.

The Cd in plants is relatively very mobilize, although the translocation of Cd through the plant tissues may be restricted because Cd is easily held mainly in exchange sites of active compounds located in the cell walls (Cunningham *et al.,* 1975).

CONCLUSION

From the above discussion we can concluded that canola behaved as an accumulate for Mn, Zn, Ni and Cd and could be useful indicator of the metal availability for plants and the effectiveness of possible remediation treatments in soils contaminated with heavy metals. However, in this pluri-contaminated soil polluted water or canola is useful for metal phytoextraction, due to higher metal accumulation capacity.

Abo El-Naga *et al.* (1999), Zein *et al.* (2007) recommended that attention must be earnestly given to protect the environment and commitments to the latest law issued 1994 in Egypt, must be obligatory under taken for these factories to prevent them from polluting agricultural soils by wastes. A part from the roles played by pollution control and soil chemistry, plant breading can make a vital contribution through the selection and utilization of crop genotypes which accumulate the least heavy metals.

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أستخدام نبات الكانولا لاستخلاص العناصر الثقيلة من الأراضى المروية لمدى بعيد بمياه الصرف الملوثة

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أقيمت تجربة بمحطة البحوث الزراعية بالأحواض الأسمنتية بسخا – كفر الشيخ – مصر للموسم الشتوى ٢٠٠٨-٢٠٠٩ وذلك لدراسة تراكم العناصر الثقيلة: المنجنيز ، النحاس ، الزنك ، النيكل ، الكادميوم ، الرصاص ومدى سهولة استخلاص هذه العناصر بواسطة الجذور والسيقان والاورا والبذور والزيت تحت تأثير معاملات المياه حيث زرعت الكانولا فى أحواض وكانت الأبعاد (١٠٠ × ٧٠ × ٩٠ سم) وملأت بأراضى طينية ورويت بثلاث أنواع من المياه منذ سنة ١٩٨٧ ونوعية المياه الثلاثة W1 مياه النيل (مياه ذات نوعية جيدة) ، W3 (مياه صرف رديئة النوعية) ، W_2 مياه خليط (٥٠% من ماء النيل + ٥٠% من مياه الصرف) واستخدم فى توزيع المعاملات قطاعات كاملة العشوائية بأربع مكررات.

وأوضحت النتائج ما يلى:

- زاد استخدام مياه الصرف فى الرى من قيم التوصيل الكهربى ECe ، SAR ، الكاتيونات والانيونات الذائبة فى مستخلص عجينة التربة المشبعة وكذلك محتوى التربة الكلى والمستخلص بـATPA من العناصر الثقيلة عن تلك المستخدم فيها المياه المخلوطة أو مياه النيل فى الرى.
- لم يكن هناك تأثير معنوى لنوعية المياه على أى من طول plumule ومعامل التمدد معامل التأدرت والدهن الخام ونسبة الرماد فى بذور الكانولا.
- أفضل طول للجذير radical والبروتين الخام تم التحصل عليها فى بذور نباتات الكانولا التى رويت بمياه الصرف.
- كان محتوى أجزاء النبات من العناصر الثقيلة يتبع المتسلسلة: الجذور > السيقان > الأوراق > البذور > زيت.
- وكانت أعلى القيم بصفة عامة عند استخدام مياه الصرف فى الرى.
- وجد أن هناك تأثير عالى المعنوية لنوعية المياه المستخدمة فى الرى على محتوى الكانولا لكل من العناصر الثقيلة المدروسة.
- كان الزيت المستخلص من بذور الكانولا هو أقل أجزاء النبات احتواء على العناصر الثقيلة المدروسة
- اتضح ان العناصر الثقيلة وخاصة الزنك والمنجنيز والكادميوم والنيكل والرصاص تتراكم فى نبات الكانولا بكميات كبيرة وهذا يجعله أن يكون دليل مفيد للدلالة على مدى جاهزية العناصر فى الاراضى الملوثة بالعناصر الثقيلة ويمكن استخدامه فى استخلاص هذه العناصر من الاراضى الملوثة بها.