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REUSE OF LOW QUALITY WATER SOURCES FOR IRRIGATION AND MANAGEMENT OF SOIL HEAVY METALS

Soliman, S. M.* ; M. E. El-Nennah; Sherien M. El-Degwy*;, A. M. Gadalla* and B. A. Al-Natsheh****

***Atomic Energy Authority, Nuclear Research Center, Soil and Water Research Department, Abou-Zaabl, 13759, EGYPT,**Corresponding Author:galalyehia@yahoo.com, and **Soil Science Department, Faculty of Agriculture, Ain Shams University, Cairo, Egypt**

ABSTRACT

A pot experiment was carried out under green house condition to evaluate the impact of wastewater sources on soil heavy metals content (Fe, Cu, Zn, Mn, Cd and Pb) as well as plant growth and its heavy metals content. In this regard, we aimed to reuse both the low quality wastewater and heavy metal contaminated soil.

This study revealed that sewage effluent and industrial wastewater are the main sources of pollution of the water body when used in irrigation. They contain variable amounts of heavy metals lead to increase concentration of metals in the soil and vegetation. Soil, plant and water quality monitoring, together with the prevention of metals entering the plant, are a prerequisite in order to prevent potential health hazards of irrigation with sewage-fed or industrial wastewater.

Heavy accumulation of metals in root from soil and subsequent translocation to other parts of plants is important for the selection of plant specially crops and vegetables. To avoid entrance of metals into the food chain, municipal or industrial waste should not be drained into rivers and farmlands without prior treatment.

Keywords: Heavy Metals, Plant Growth, Wastewater Management.

INTRODUCTION

Industrial wastewater is got from manufacture. Most industrial wastewater can be discharged in small proportions into the sewage system either with or without prior treatment depending upon its characteristics and quantity. Effluents with high organic load with toxic or corrosive properties require pre-treatment before discharge to the sewers (Farouq, 2003).

Heavy elements are naturally present in abundance and enter the water cycle through a variety of geochemical processes; many elements are also added to water by man induced activities such as manufacturing, construction and agriculture. It is well recognized that process of heavy elements in the environment can be detrimental to a variety of living species, including man; effects of such metals can be easily distinguished from other toxic pollutants (Schwartz and Rimkus, 1991). They evaluated the fresh water contains of heavy elements and reported that values were 0.01-3, 0.06-120 and 0.2-100 mg\l for Cd, Pb, and Zn, respectively. In Egypt Abd-Elshakour (1982) evaluated the status of heavy elements in water samples collected along the river Nile and showed concentrations variable between 0.02-2 mg\l for Cd, 0.05-10.8 mg\l for Pb, and 0.66-36 mg\l for Zn.

Gillet and ponge (2002) showed that certain elements are more toxic when being in combination with other metals or under specific environmental conditions. For example, cadmium toxicity increases in the presence of copper or zinc; copper and zinc may be more or less toxic depending on other water quality conditions such as pH and temperature, lead being more toxic if the dissolved oxygen concentration is low.

Metals accumulated in soils are depleted slowly by leaching, plant uptake erosion, or deflation. In addition to natural constituents, heavy metals may enter the soil via atmospheric deposits, discharge from sewage treatment plants, and application of sewage sludge as organic fertilizer or land fill material, polluted irrigation water and beneficial agricultural additives (Elsokkary, 1996).

Mosalem (1997) revealed that increasing irrigation period of sewage effluent at El-Gabal El-Asfar farm has increased both DTPA extractable and total Fe, Zn, Mn, Cu, Ni, Pb, Co and Cd elements in soil sample.

According to Calaci *et al.,* (2005) soil metal are a great environmental problem and can be derived from different sources in any soil depends materially on the nature of the parent material, since a soil inherits a certain stock of elements from its parent material.

Benaissa and Elouchdi (2003) were showed that zinc and lead to be bound up to either clay or silt fractions. Addition of organic matter(O.M) amendments, such as compost or manure, through affecting the soil pH and redox potential, is a common practice for immobilization of some nutrient heavy metals, to facilitate re-vegetation of contaminated soils (Fumic *et al*., 2003). Indicated effects should be dependent on the nature of the organic matter, their microbial degradability as well as the soil type and concerned element (Walker *et al.,* 2004). There is a long history of contamination accumulating in soil due to number of wrong practices. Soils contain and receive heavy metals (such as Pb, Cd As, Se, Cu, Zn, Hg) that can accumulate to very high contents and find their way to plants reaching toxic level, (Berthelin and leyval. 2000).

This work aimed to evaluate the reuse of some wastewater sources varied in their content of heavy metals as unconventional alternative irrigation water sources.

MATERIALS AND METHODS

Pot experiment was carried out under greenhouse conditions at Soil and Water Research Department, Nuclear Research Center, Atomic Energy Authority; to evaluate the management of wastewater to be used as unconventional water resources in sustainable agriculture systems.

Three main water types were used in this study. Chemical analysis of wastewater was listed in Table (1), and its chemical analysis was carried out according to Page *et al.,* (1982). Four crops, i.e. radish, canola, clover and turnip were used as tested plants. In this experiment two soil types were used, sandy soil and loamy sand soil. Each one consists of three treatments; the first was control irrigated with fresh water from Ismaelia canal and the second irrigated with industrial wastewater collected from the main drainage of Aluminum Sulfate Factory and the third irrigated with wastewater drained from El-Gabal El-Asfar farm station.

Five kg of experimental soil was packed in a pot and thoroughly mixed with phosphorous and potassium fertilizers at recommended rates.

Surface irrigation system was used. At the beginning, irrigation took place using fresh water, and immediately after sowing seeds were covered with a thin layer of sand and the estimated water volume to bring the soil to its field capacity was added for each pot.

The treatments were replicated three times and statistically arranged in a completely randomized block design**.** All data were subjected to ANOVA analysis according to Snedeccor and Cocharn (1982).

RESULTS AND DISCUSSION

Quality assessment of wastewater used for irrigation

Standard wastewater used for irrigation (FAO, 1992; WHO, 1989), showed that pH values of fresh water, sewage effluent and $Al_2\ (SO_4)_3$ industry water were 7.1, 7.65 and 8.65, respectively. EC was higher in the sewage effluent and industrial wastewater but in the permissible limit. The highest cations concentrations were Na^+, 13.5 and Ca^{+2}, 11.52 C mol/kg in water from the industrial wastewater; while the highest anion concentrations were Cl^- and HCO_3^- in water from the sewage effluent. The use of sewage water or industrial wastewater is not accepted due to have several pollutants, so its reuse imposes risk by adversely affecting the environment and human health. All water parameters exceeded the standard levels of irrigation water as described by WHO (1993). In addition, the continuous use of sewage water in irrigation can induce N and P leaching to the ground water (Chaney, 1990) which could induce eutrophication (Pierzynski *et al.,* 2000).

The wastewater contains considerable amounts of nitrate, phosphate and potassium which are considered essential nutrients for improving plant growth and soil fertility and productivity levels. However, as a result of long-term irrigation with domestic sewage or industrial effluent, some heavy metals concentrations in soils of the irrigated area were found significantly higher than the background values (Bourennane *et al*., 2006; Dere *et al.,* 2007 and Rodriguez *et al.,* 2008).

Also, results showed that the average values in fresh water (C mol/kg) of Mn, Cu, Zn, and Fe, were 0.05, 0.02, 0.40, 0.23, and not detected for Cd and Pb, respectively. Due to disposal of industrial effluents, the wastewater have higher contents of Cu by 6 times, Fe by 1.5, Cd by 3, Co by 80 times for sewage effluent above the permissible limits. For $Al_2\ (SO_4)_3$ industry wastewater, the values were 3.5, 2.0, 1.7, 1.2, 2.0, and 4.4 times for Mn, Cu, Zn, Fe, Cd and Co over the permissible limits, respectively. These results show that both two wastewaters may also become a potential hazard for crops irrigated with them. Also, results show that Pb content in wastewaters did not exceed the permissible concentration limit. Remaining metals like cobalt, cadmium, lead and zinc values as compared to FAO (1992) and WHO (1989) standards are not suitable for irrigation. Ahumada *et al.*, (1999) found that high concentrations of Cd content in untreated wastewater increased their concentrations in the applied soils. Boruvka *et al.*, (1996) reported that the high concentration of Cd content in floodwater increased its concentrations in the contaminated soils. Setia *et al.,* (1998) concluded that sewage water contained 4 to 10 times more Cd content than well water.

Impact of using sewage effluent and industrial wastewater in irrigation on plants

Dry matter

Higher growth was recorded by tested plants grown in sandy loam textured soil compared to sandy one (Table 1). In this concern, different plants grown on the same soil could be arranged in the following order: Canola > Turnip > Radish> clover.

Table (1): Shoots and roots dry matter yield (gm/pot) of radish, turnip, clover and canola plants grown on two soils sandy and sandy loam soil irrigated with different wastewaters.

Dry matter gm/pot	Loamy sand soil					
	Fresh Water		Industrial Water		Sewage Effluent	
	Shoot	Root	Shoot	Root	Shoot	Root
Radish	13.52	6.11	13.83	6.41	14.24	5.68
Turnip	15.01	7.73	17.18	5.10	15.63	6.30
Clover	7.24	4.17	6.59	3.06	7.67	4.68
Canola	19.78	3.31	20.01	2.86	19.80	4.23
Sandy Soil						
Radish	7.91	8.15	10.11	4.53	10.55	12.06
Turnip	7.92	12.49	7.72	9.18	6.20	13.39
Clover	5.65	5.16	4.89	4.10	4.83	3.19
Canola	12.26	8.67	12.45	7.60	11.38	8.16
LSD (0 - 0.5)		**Shoot,**	**2 - 606**			
		Root,	**2 - 899**			

Also, results showed that higher growth (shoots + roots weights) was recorded by plants irrigated with sewage effluent followed by plants irrigated with industrial wastewater and then fresh water. The effect on plant growth was more pronounced for the abovementioned descending order. Cheung *et al.,* (2000) stated that higher productivity two legume species resulted from the sewage sludge compost due to a greater contribution of plant nutrition in the compost. Ye *et al.*, (2001) showed that application sewage effluent can effectively improve growth Sesbania species, this may be due to enrichment nutrients e.g., C, N, P and K and reduction of metal toxicity. In general, care should be exercised for irrigation of raw edible vegetables by wastewater effluent.

Heavy metals content in the tested plants

Heavy metal depositions are associated with a wide range of sources. Additional potential sources of heavy metals in field locations in urban and per urban areas include irrigation water contaminated by industrial effluent leading to contaminated soils and vegetables.

Plant species and varieties differ widely in their abilities to absorb, accumulate and tolerate heavy metals. Contents of Fe, Zn, Mn, Cu, Co, Cd and Pb in shoots and roots of tested plants grown on the studied soils irrigated with waters of different qualities are illustrated in Table (2). The results indicate that Fe, Zn, , Mn and Cu contents in the plant were the highest in the plants grown in the soils receiving wastewater (sewage or industrial) comparing with the plants irrigated with fresh water. In this concern, the maximum concentration of iron was in radish (18.8-199.8 µg/g) and the minimum in canola 38.5, 69.3 (µg/g). Mn was found in the same trend for the abovementioned plants. Mn had the maximum concentration in turnip (3.9-13.2 µg/g) and minimum in radish (2.3-10.9 µg/g). Copper content was relatively higher in canola (22.2-61.1 µg/g) while clover had the least (21-51.8 µg/g). Cobalt level was highest in canola (15.6-35.2 µg/g) and least in radish (2.5-26.4 µg/g). Cadmium concentration was highest in canola (2.4-35 µg g) and turnip shows the least (0.9-31.8 µg/g). Lead showed the maximum concentrations in clover (29.4-84.9 µg/g) and the minimum concentrations in canola (32.6-54.3 µg/g). Several researchers reported an increase in micronutrients uptake by the plant increased in leaves of plants irrigated with sewage water than that irrigated with fresh water (Mohammad and Mazahreh, 2003; Brar *et.al,* 2000).

Iron and manganese

In general, the soil Fe and Mn concentrations are not reported in studies focusing on soil heavy metal content because they are not contaminant elements as appeared in Table (2). Both metals are important in plant nutrition as they are essential crop micronutrients. Manganese plays an important role in oxygen photosynthesis. These elements can be in insoluble forms in calcareous soils causing deficiencies (e.g. ferric chlorosis).

Zinc

Table (2) showed that maximum Zn tolerance for human health has been established for edible parts of crops is 20mg/kg by Chinese Department of Preventive Medicine (1995). WHO (Codex, 2001) maximum permitted level for Zinc in vegetables is 100 mg/kg. By this way, the concentration of Zn in vegetables was as fallow: Green radish>turnip>canola>clover. Data showed that there was not any pollution in most tested plants except radish plants, in compared to WHO standard level.

Knowledge of Zn toxicity in humans is minimal. Research results about the effects of excess Zinc on plant growth of three selected vegetables cabbage, celery and Spinach showed that excess Zn in growth media caused toxicity to all three vegetable crops (Long, *et al.,* 2003).

Copper

The copper levels Table (2) found in vegetables were within safe limits in all samples. Yang *et al.* (2002) studied the response of three vegetables to Cu toxicity and found that Cu levels in both root and shoot increased, but root Cu concentration increased more sharply than shoot with increasing Cu levels in growth media. Xiong and Wang (2005) found that Cu concentration in the shoots was significantly influenced by Cu concentration in soil and increased markedly with an increase in the soil Cu concentration .

Table (2): Heavy metals content in radish, turnip, clover and canola plants grown on sandy or Loamy Sand soil and irrigated with different wastewaters.

Heavy metals ug/gm)	Loamy sand Soil						Sandy Soil					
	Control		Ind.		S.Eff		Control		Ind.		S.Eff	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
Radish Plant												
Fe	51.7	84.8	183.0	801	199.8	751	18.8	249	74.3	311	136.7	485
Zn	10.2	10.4	20.9	20.0	17.8	20.0	8.7	10.3	21.6	15.3	21.6	18.4
Mn	4.7	6.6	10.9	16.9	10.9	12.4	2.3	2.2	10.8	7.9	8.9	10.1
Cu	24.8	8.2	53.9	14.6	50.3	16.9	19.7	4.1	56.6	10.1	48.4	12.9
Co	8.9	13.6	26.5	18.2	25.8	18.4	2.5	12.1	25.6	22.8	26.4	21.6
Cd	4.1	3.2	31.0	21.6	30.3	22.4	2.8	0.8	28.2	19.5	28.2	20.3
Pb	39.5	65.3	52.4	81.5	48.5	75.7	42.9	72.6	82.8	49.7	47.6	41.4
LSD (0 – 0.03) Fe, 128.7; Zn, 13.8; Mn, 9.6; Cu, 30.1; Co, 16.2; Cd, 17.2; Pb, 165.4												
Turnip Plant												
Fe	17.1	116	143.0	949	89.0	1301	26.6	344	122.5	422	85.1	362
Zn	7.7	7.5	13.1	21.5	13.4	21.6	8.5	9.2	17.7	17.5	16.5	20.1
Mn	4.2	10.9	9.0	19.9	8.9	18.1	3.9	1.8	13.2	11.8	8.3	9.2
Cu	18.8	12.3	56.3	27.0	52.8	27.0	25.7	9.8	54.1	19.1	55.6	20.6
Co	12.2	18.9	29.3	20.3	29.6	19.7	3.10	1.01	9.64	2.01	10.26	3.01
Cd	0.9	6.0	31.9	24.6	31.8	24.8	2.1	4.2	31.8	23.2	31.2	23.8
Pb	38.6	68.5	51.3	82.5	52.0	39.2	24.8	21.6	52.9	59.3	55.5	77.8
LSD (0 – 0.03) Fe, 144.0; Zn, 10.2; Mn, 7.2; Cu, 22.7; Co, 9.8; Cd, 11.8; Pb, 147.4												
Clover Plant												
Fe	60.9	267	168.2	389	126.9	318.8	159.1	201	108.8	754	122.1	551
Zn	12.3	17.4	14.2	18.4	13.1	17.5	9.9	14.9	13.2	20.5	14.0	22.1
Mn	1.3	12.6	11.5	27.8	7.1	22.2	5.9	18.7	10.1	35.6	8.7	23.5
Cu	28.3	18.9	51.8	25.9	50.6	32.8	21.9	20.5	51.3	35.3	50.9	38.0
Co	12.8	15.3	28.8	33.0	32.9	21.5	17.4	15.4	31.9	31.0	30.8	24.6
Cd	0.9	2.7	33.6	25.8	32.6	25.4	1.3	1.7	32.3	27.0	32.5	26.0
Pb	29.4	24.4	51.5	38.6	53.1	43.5	31.9	51.4	57.8	41.6	84.9	82.4
LSD (0 – 0.03) Fe, 156.7; Zn, 10.4; Mn, 10.2; Cu, 23.2; Co, 11.3; Cd, 9.1; Pb, 94.9												
Canola Plant												
Fe	44.9	627.1	69.3	845	66.7	951	40.2	506	38.5	522	41.1	598.9
Zn	12.4	13.9	16.4	21.0	15.7	20.4	9.8	12.9	12.2	20.1	12.6	21.8
Mn	6.8	10.7	11.5	20.8	11.3	23.2	8.1	10.1	13.5	17.5	12.2	14.0
Cu	28.3	33.1	61.1	46.1	57.4	49.5	22.2	25.8	54.9	35.8	56.9	36.9
Co	23.6	22.1	35.2	24.4	33.1	21.4	15.6	16.0	31.6	32.4	30.9	20.7
Cd	2.6	1.4	34.9	26.6	35.0	27.3	2.4	1.4	34.0	27.2	34.0	26.6
Pb	32.6	36.0	51.9	78.5	54.3	72.7	43.0	37.3	49.7	44.3	48.8	41.4
LSD (0 – 0.03) Fe, 260.8; Zn, 15.1; Mn, 11.4; Cu, 28.5; Co, 17.2; Cd, 27.1; Pb, 169.1												

Cobalt

According to Table(2), in excess concentration, the hazardous effects of Co on plants indirectly lower the concentration of essential nutrients, decrease photosynthesis, reduce intercellular spaces, and disturb the structural integrity of chloroplasts and carbohydrate metabolism (Lambert and lincoe, 1971). The activity of several enzymes, including Fe-containing enzymes, is disturbed by excessive amounts of Co within the plants (Chatterjee and Chatterjee, 2003).

Cadmium

Data in Table (2) showed that Cd concentration mostly were appeared in leafy vegetables and were in follow order: canola>clover>Radish=clover. WHO standards for Cd in vegetables are 0.1 mg/kg (Codex, 2001). Torabian and Mahjouri, (2002) show that Cadmium accumulation in plants irrigated with wastewaters in South Tehran is in the following order of ranking. Spinach<Radish>Coriander<Mint. The amount of Cadmium accumulation in the aerial parts of a plant is higher than in the parts below the ground (root).

Ranos *et al.,* (2002) showed that there is a direct relation between the levels of presence of cadmium in the root zone end its absorption by plant.

Lead

The main cause for concern in terms of contamination of vegetables by heavy metals relates to Lead (Pb) Table (2). Although, a maximum Pb limit for human health has been established for edible parts of crops by WHO standards is 0.3 mg/ kg (Codex, 2001), data showed that in all plants, lead concentration is more than permitted level, so they are not suitable for consumption. In many plants, Pb accumulation can exceed several hundred times the threshold of maximum level permissible for human (Wierzbicka, 1995). On the whole, all plants that were studied in this study were contaminated by lead and they were toxic to consumer.

Heavy metals content in the tested soils irrigated with different wastewaters

The analysis of heavy metal concentrations in agricultural soils is, therefore, critical for policy making orientated toward reducing heavy metal inputs to soil and guaranteeing the maintenance or even the improvement in soil quality. In addition, the concentration of industrial areas near villages and the presence of small industries in the agricultural zones could increase the concentration of pollutants, which should be assessed.

DTPA-extractable heavy metals

Results given in Tables (3, 4) showed the DTPA-extractable Fe, Zn, Mn, Cu, Co, Cd and Pb in the soils after cropping with radish, turnip, clover and canola plants as affected by irrigation with tap and wastewaters. The values of the available heavy metals were varying according to water sources, type of cultivated plants and soil texture. In this concern, generally, concentrations of heavy metals in the soil irrigated with either sewage water or industrial one were increased compared to the soil irrigated with tap water. The increasing availability of the concerned heavy metals in the soil irrigated with raw sewage water could be attributed to increasing the total contents.

Matloub and Mehana (1998) showed that the use of sewage effluent from Ismailia treated plant or mixed with Nile water for irrigation increased the levels of DTPA extractable heavy metals (Fe, Zn, Cu, Pb, Co and Cd) compared to the Nile water. However, the obtained levels were lower than the maximum permissible limits and the normal ranges.

Table (3): Heavy metals content (ug/g) in tested soils before cultivation

Heavy metals content (ug/g)	Sandy Soil		Sandy Loam Soil		Guidelines for soil total (ug/g) A Total
	Total	DTPA	Total	DTPA	
Fe	27.68	2.29	97.07	6.16	P 50000
Zn	2.37	1.14	24.30	7.47	300
Mn	9.54	3.93	22.03	11.96	P 2000
Cu	1.42	0.63	1.38	2.92	1500
Co	0.72	0.47	0.78	0.54	50
Cd	0.023	0.027	0.070	0.24	3
Pb	7.82	3.82	7.99	4.09	100

A: after (Ewers, 1991) and P: after (Pendias, and Pendias, 1992)

Several authors reported that solubility of most heavy metals, dissolution and precipitation processes of soil minerals are controlled by soil pH (Elinder, *et.al.,* 1988). Although other soil scientists believe that soil chemistry is also very important in controlling the solubility of trace elements in the long-term, (FAO, 1981) pay no heed to the characteristics of the soil. The highest values recorded with Fe and Mn while the lowest values were with Cd and Co. This indicates that the increases in total heavy metals contents in the soils are in forms readily extractable by the DTPA. Also, most of the added metals could be present in a soluble form due to irrigation with wastewater.

Total heavy metal content

The total amounts of Fe, Mn, Zn, Cu, Co, Cd and Pb as affected by the different soil texture and wastewater irrigation are shown in Tables (3, 4) before and after cropping by radish, turnip, clover and canola plants. Data reveal that the total content of these elements differed according to water source used for irrigation. The values of the elements followed the sequence: Fe>Mn>Zn>Cu> Pb>Co>Cd. However, it can be observed that these micronutrients being immobile in the soil tended to accumulate in the topsoil. Generally, concentrations of such heavy metals in the soil irrigated with wastewater were higher than fresh water. The increasing in total amounts of heavy metals could be mainly due to repeating irrigation with treated water. Other researchers found that soil micronutrients were higher and mainly in the top soil then decreased within depth (Lawes, 1993). In long term wastewater irrigation (80 years), Christina Siebe (1998) found that the contents of soil Cu, Zn, Mn, and Fe were increased compared to the soil irrigated with potable water. It should be mentioned that mismanagement of wastewater irrigation especially under long term application can lead to toxicity problems by heavy metals and high levels of nutrient accumulation, and deterioration of soil and crop quality parameters. Accumulation of micronutrients and heavy metals from wastewater application could be caused directly from the wastewater composition or indirectly through increasing solubility of the indigenous insoluble soil heavy metals as a result of the chelation or acidification action of the applied wastewater (Papadopoulos, 1995)

Iron and manganese

In general, the soil Fe and Mn concentrations are not reported in studies focusing on soil heavy metal content because they are not contaminant elements. Both metals are important in plant nutrition as they are essential crop micronutrients. Therefore, Fe deficiency does not seem to be due to insufficient total soil Fe content but to the formation of insoluble compounds. However, further study would be necessary to properly assess deficiency processes of these metals in the study area.

Copper

The normal Cu content of agricultural soils is 5 to 50 mg/ kg. Concentrations below 8 mg/ kg could indicate a deficiency for some crops as Cu is an essential micronutrient **(**McBride, 1994; Kabata-Pendias and Pendias, 2001). In this study, all sampled soils were in the normal range and none exceeded the reference value.

Zinc

The Zn concentration in agricultural soils varies from 10 to 300 mg/kg. It is abundant in sedimentary materials and clayey soils (Kabata-Pendias and Pendias, 2001), such as alluvial and alluvial-colluvial soils. In this work, tested soils contained less Zn than the maximum permissible concentration.

Cobalt

Generally, the Co content of basic and sedimentary rocks is low and subsequently, soil Co concentrations in soils formed from these rocks are usually low. Thus, a significant increase in soil Co content as a result of human activity has not occurred.

Cadmium

Cd content was increased due to the use of phosphatic fertilizers and other agrochemicals used on cropping system.

Different international authors fix a normal Cd range of 0.07 and 1.1 mg / kg (Alloway,1990;Kabata-PendiasandPendias,2001).Concentrations above 0.5 mg / kg could reflect the influence of human activity (McBride, 1994).

In the study area, six plots exceeded this value, indicating a slight increase in this heavy metal in relation to the normal level. Therefore, the Cd contents of these soils did not reach toxic levels. However, further studies are required to identify possible increase in the content due to the presence of contamination sources.

Lead

In agricultural soils, Pb could also be from the application of agrochemicals. Concentrations over 100 mg/kg (Kabata-Pendias and Pendias, 2001) would represent potentially contaminated soils. These levels were not reached in the studied soils before or after cropping system. Although current Pb levels are not high, further studies are recommended to identify possible increases in soil Pb concentrations in these soils, given the human origin of Pb in some soils in the study area.

Table (4): Heavy metals content (ug/g) in soils which irrigated with different wastewaters after cropping with radish, turnip, clover and canola plants.

Heavy metals ug/g)	Loamy sand Soil						Sandy Soil					
	Control		Ind.		S.Eff		Control		Ind.		S.Eff	
	Total	DTPA	Total	DTPA	Total	DTPA	Total	DTPA	Total	DTPA	Total	DTPA
Radish Plant												
Fe	263	11.1	380	22	422	26.3	16.8	0.14	32.5	0.28	33.0	0.46
Zn	2.86	0.39	4.22	0.46	4.50	0.57	0.91	0.06	1.14	0.06	1.38	0.27
Mn	13.6	1.34	25.2	3.61	13.0	2.15	1.90	0.86	4.62	0.98	2.43	0.97
Cu	1.60	0.15	3.42	0.15	1.80	0.10	0.99	0.02	1.23	0.02	1.22	0.02
Co	4.94	0.09	9.18	0.13	9.20	0.14	3.67	0.03	8.35	0.07	8.05	0.13
Cd	1.56	0.01	0.28	0.02	0.30	0.02	0.12	0.00	0.13	0.01	0.23	0.02
Pb	7.48	0.33	11.67	0.67	12.80	0.77	6.06	0.14	8.05	0.41	10.81	0.36
Turnip Plant												
Fe	20.0	1.10	42.9	1.60	89.0	2.20	19.8	0.15	34.8	0.33	44.4	0.57
Zn	2.88	0.32	4.28	0.57	5.61	0.61	0.93	0.21	2.57	0.37	2.64	0.44
Mn	4.66	2.84	23.6	3.24	14.58	2.48	2.50	0.38	5.21	0.39	8.71	0.41
Cu	1.77	0.17	6.28	0.17	4.78	0.19	0.83	0.02	1.70	0.03	1.01	0.03
Co	5.64	0.12	11.0	0.19	11.5	0.22	3.10	0.06	9.64	0.14	10.26	0.07
Cd	0.94	0.01	0.35	0.02	0.31	0.01	0.20	0.01	0.32	0.01	0.34	0.01
Pb	8.30	0.30	12.2	0.64	14.4	0.72	7.01	0.22	10.5	0.38	13.41	0.32
Clover Plant												
Fe	310	13.9	353	14.5	334	13.6	39.63	4.16	46.50	6.28	51.33	8.42
Zn	2.96	0.58	5.84	1.56	6.13	1.87	1.32	0.31	2.86	0.86	4.44	1.02
Mn	8.91	2.21	15.8	4.64	12.96	3.76	1.99	0.27	3.25	0.45	2.66	0.43
Cu	2.61	0.19	3.53	0.27	5.65	0.43	0.51	0.03	0.83	0.04	0.93	0.04
Co	6.14	0.12	12.4	0.16	12.86	0.22	3.19	0.09	11.73	0.11	12.2	0.11
Cd	0.12	0.02	0.39	0.01	0.37	0.01	0.06	0.00	0.32	0.01	0.35	0.00
Pb	5.96	0.48	14.4	0.76	14.43	0.81	4.63	0.31	10.87	0.39	11.4	0.41
Canola Plant												
Fe	272	10.3	340.	13.8	356	12.8	30.20	2.31	40.0	4.39	39.0	5.42
Zn	2.67	0.28	6.70	2.99	8.34	3.46	1.53	0.18	2.50	0.93	3.55	0.97
Mn	12.8	2.46	19.2	3.53	14.7	2.97	2.04	0.38	3.25	0.62	3.27	0.92
Cu	2.22	0.32	5.60	0.52	3.93	0.63	0.90	0.05	1.86	0.07	1.07	0.06
Co	11.2	0.11	15.9	0.15	14.6	0.22	9.27	0.10	12.5	0.08	11.3	0.13
Cd	0.18	0.01	0.46	0.02	0.46	0.02	0.13	0.01	0.41	0.01	0.42	0.02
Pb	9.11	0.32	13.8	0.80	15.1	0.66	7.86	0.22	11.1	0.41	14.2	0.45

Conclusions

The study reveals that sewage is the main source of pollution of underground water and irrigation with sewage-contaminated water containing variable amounts of heavy metals leads to increase in concentration of metals in the soil and vegetation. It should be mentioned that mismanagement of wastewater irrigation especially under long term application can lead to toxicity problems by heavy metals and high levels of nutrient accumulation. Accumulation of micronutrients and heavy metals from wastewater application could be caused directly from the wastewater composition or indirectly through increasing solubility of the indigenous insoluble soil heavy metals as a result of the chelation or acidification action of the applied wastewater.

Therefore, these concerns should be essential components of any management of wastewater irrigation. The proper management of wastewater irrigation, soil fertility and quality parameters are required to ensure successful, safe and long term reuse of wastewater for irrigation to increase levels of plant nutrients and soil organic matter.

Heavy accumulation of metals in root from soil and subsequent translocation to other parts of plants is important for the selection of plant specially crops and vegetables. Plant accumulating least quantity of metals in edible parts, with the concentration within the permissible limit than the verity of species can be selected for the cultivation on the field having high level of metal contamination.

From the results, it could be concluded that reuse of wastewater for long term in agriculture can have devastating results on the soil, environment, especially in arid and semi arid regions.

To avoid entrance of metals into the food chain, municipal or industrial waste should not be drained into rivers and farmlands without prior treatment.

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إعادة استخدام مصادر المياه متدنية الجودة في الري وإدارة المعادن الثقيلة في التربة

سليمان محمد سليمان* ؛ محمد النته؛ شيرين محمد الدجوي*؛ عبد النبي مصليحي جاد الله* و باسل النتشه****
*** قسم بحوث الاراضي والمياه-مركز البحوث النووية-هيئة الطاقة الذرية**
****قسم الاراضي-كلية الزراعة جامعة عين شمس**

اجريت تجربة اصص في الصوبة لتقدير اثر مصادر المياه المتدنية الجودة علي محتوي التربة من المعادن الثقيلة (Fe, Cu, Zn, Mn, Cd and Pb) كمؤثر علي نمو النبات واحتوائه علي العناصر الثقيلة. وفي هذا الصدد نأمل في إعادة إستخدام كلا من المياه المتدنية الجودة وإزالة آثر تلوث التربة بالعناصر الثقيلة.

اشارت التجربة الي ان الري بمياه الصرف الصحي والصرف الصناعي هي المصادر الاساسية لتلوث المياه الجوفية وذلك لإحتوائها علي كميات مختلفة من المعادن الثقيلة التي تؤدي الي زيادة تركيزها في التربة والنباتات المزروعة بالتربة. وجد أن الإهتمام بدراسة التربة والنبات وجودة المياه يؤدي لمنع دخول المعادن الي النبات وبالتالي منع الإصابة بالأمراض نتيجة الري بمياه الصرف الصحي والصناعي.

وجد انه عند معرفة نسبة تراكم المعادن الثقيلة في جذور النبات (من التربة) وانتقالها لباقي اجزاء النبات يمكن علي اساسها اختيار اصناف النباتات التي يمكن زراعتها خاصة في حالة المحاصيل والخضروات.

التوصية الاساسية هي منع الصرف بكل انواعه في مياه النيل او في الاراضي الزراعية وذلك قبل معالجتها.

قام بتحكيم البحث

أ.د / السيد محمود الحديدى	**كلية الزراعة – جامعة المنصورة**
أ.د / يحى جلال محمد جلال	**مركز البحوث النوويه – هيئة الطاقه الذريه**