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Heavy Metals Uptake by Several Crops Grown in Soils Irrigated with Sewage Wastewater in Assiut: Case Study

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EXCESSIVE accumulation of heavy metals in agricultural soils may not only result in environmental contamination, but leads to elevated heavy metal uptake by plants which may affect food quality and safety. The research work here studied heavy metal concentrations in wheat, corn, sorghum, bean, clover, onion, garlic and squash plants, which were irrigated with untreated sewage water in El-Madabegh and five other villages near Assiut City. The plants were analyzed for the content of Fe, Mn, Zn, Cu, Cd, Ni and Pb.

Cadmium, Zn, Cu, Ni and Pb concentrations in all studied soils and plants were relatively high due to irrigation with sewage wastewater compared to those irrigated with underground water.

This study highlights the potential hazard for the health of humans and animals due to uptake of high concentrations of heavy metals, especially Cd, Ni and Pb, by several crops.

The high concentration of heavy metals in soils is reflected by higher concentrations of metals in plants, and consequently in animal and human bodies.

It has been the interest of the public to know whether vegetables, fruits and food crops cultivated in polluted soils are safe for human consumption, especially now that the environmental quality of food production is of major concern (Chiroma *et al*., 2003). Vegetables as well as cereals and legumes constitute an important part of the human diet since they contain carbohydrates, proteins, as well as vitamins, minerals and trace elements (Abdala and Chmtelnicka, 1990).

Using wastewater in agriculture has been, therefore, practiced in several countries (Gholamali *et al*., 2012; Ahmed & Al-Hajri, 2009 and El-Sawaf, 2005). The sewage effluents however are considered not only a rich source of organic matter and other nutrients but also they elevate the level of heavy metals like Fe, Mn, Cu, Zn, Pb, Cr, Ni, Cd and Co in increasing soils (Mapanda, 2005 and Preeti & Fazal, 2013). Heavy metals are one of a range of important types of contaminations that can be found on the surface and in the tissue of fresh vegetables (Preeti and Fazal, 2013). Excessive accumulation of heavy metals in agricultural soils through wastewater irrigation may not only result in soil

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contamination, but also affect food quality and safety. Heavy metals are easily accumulated in the edible parts of plants (Arora *et al*., 2008).

Plant species have a variety of capacities in removing and accumulating heavy metals, so there are reports indicating that some species may accumulate specific heavy metals, causing a serious health risk to human health when plants based food stuff are consumed (Smith *et al*., 1996 and Okoronkwo & Onwuchekwa, 2005).

Plant species varied in their ability to absorb the micro and maco-elements from soils and water depending on the selectivity phenomenon (McGrath *et al*., 1997). Large differences in accumulation of heavy metals by cereal and legume crops have been reported (Kumar *et al*., 1995). Dicotyledonous crop plants tend to accumulate more metals than monocotyledonous crops (Kabata and Pendias 1992).

Leafy vegetables like cauliflower, cabbage, spinach, etc., grow quite well in the presence of sewage water (Nrgholi, 2007), whereas vegetables such as radish are sensitive to sewage water (Ellen *et al*., 1990). Vegetables grown by the use of sewage water contain many heavy metals, which cause serious health hazards to the community and animals as well. This concern is of special importance where untreated sewage is applied for long periods to grow vegetables in urban lands.

In Assiut City, municipal wastewater from different sources is collected at El-Madabegh Village, which lies 8 km northwest of Assiut City. Several cereal and vegetable crops are being grown by the farmers in El-Madabegh Village over decades. Farmers irrigate the agricultural soils using either sewage water, or underground water and sometimes mix either type with water from Ibrahimia canal. The objective of this study is to evaluate the quality status, in terms of heavy metals content, of several vegetable and cereal crops under agriculture in soils of six villages near Assiut City being irrigated with sewage wastewater, or underground water.

Materials and Methods

El-Madabegh county sewage water management system is located 6 km north-west of Assiut City. It uses aeration, short-term storage and slow rate irrigation of approximately 90% of the influent originates from domestic sources, most of which are nonorganic chemical manufacturing and chemical related. An average of $80x10^{3}$ m^{3}/d of sewage water is conveyed to the system by collection network of gravity sewers and pumping stations. Over decades (40-45 years), without any other pretreatments the municipal sewage water coming from the sewers is dumped in water channel to irrigate several crops in an area of 8000-10000 feddan (1 feddan = 1.038 acre) distributed over six villages, namely ElMadabegh, Mankabad, Ellwan, Bani Hussein, Bani Ghalleb and Gahdam. Since these soils have been irrigated with untreated sewage water for a long time, it is expected to be contaminated with heavy metals (Gomaa, 2001 and Kamel, 2008).

Various vegetable and cereal crops were cultivated in the soils irrigated with sewage wastewater during the summer and winter seasons of 2011/2012.

Soil

Several sub-samples from the surface layer (0-30 cm) were taken in plastic bags for determination of the soil chemical and physical properties. The soil was air-dried and sieved to ~2 mm. Particle size distribution was determined following the method described in Chapman and Pratt (1961). Soil pH and electrical conductivity (EC) were measured in 1:2.5 soil-water suspension after 1 hr end-over-end shaking at 25 °C. Soil (1.0 g) was digested with nitric and perchloric acid mixture (Baker and Amacher, 1982) for measurement of the total concentrations of Fe, Mn, Zn, Cu, Cd, Ni and Pb. Soil available Fe, Mn, Zn, Cu, Cd Ni and Pb were extracted by diethylenetriaminepenta-acetic acid following Lindsay and Norvell (1978). The extracted elements were determined using a flame-atomic absorption spectrometer (GBC, 906AA). The soil physical and chemical properties of the soil irrigated with sewage water (SW) and the sewage wastewater are presented in Elgharably *et al.* (2014).

Plants

Eighteen plant samples were separately collected from each crop of the following: wheat, corn, sorghum, bean, clover, onion, squash and garlic, which farmers have cultivated in the six locations under this study. The samples were collected from the sites where the soil samples were collected.

Shoots were collected randomly at the harvest time. The samples were washed thoroughly with tap water followed by distilled water to remove adsorbed elements. Samples were cut to small pieces, air dried for 2 days and kept in hot air oven at 70 °C for 4 hr. Dried samples were ground and then acid-digested (2:1 HNO_3: $HClO_4$ acid mixture). Digested solution was cooled, filtered and made up to 100 ml with distilled water and stored in glass bottles for analysis. The concentration of heavy metals and micronutrients in the digests solutions was measured using the atomic absorption spectrophotometer (GBC300).

Statistical analysis

Data were subjected to analysis of variance using MStat, a micro-computer program. In tables, values are means (n=18, or 3) ± the standard error (SE). In figures, error bars represent SE.

Results and Discussion

Concentrations of Fe, Mn, Zn, Cu, Cd, Ni and Pb in the shoot dry matter (DM) of wheat, corn, sorghum, bean, clover, squash, onion and garlic are presented in Table 1.

TABLE 1. Shoot nutrient content (mg kg^{-1} dry matter) of crops irrigated with sewage water (SW) or underground water (UW) in El-Madabegh Village near Assiut City .

Crop	Irrigation type	Fe	Zn	Mn	Cu	Cd	Ni	Pb
		mg kg^{-1} dry matter						
Wheat	UW	200.0 ± 9.5	22.0 ± 3.2	30.0 ± 4.1	2.0 ± 1.2	0	0.5 ± 0.2	0.2 ± 0.5
	SW	231.3 ± 15.1	40.0 ± 5.1	54.5 ± 2.3	10.0 ± 2.1	8.0 ± 1.0	6.7 ± 1.2	18.1 ± 0.2
Corn	UW	251.0 ± 10.1	38.0 ± 3.5	38.0 ± 5.5	9.0 ± 0.9	0	1.0 ± 0.4	1.2 ± 0.4
	SW	391.5 ± 13.1	75.0 ± 6.3	51.2 ± 1.5	11.4 ± 1.5	16.5 ± 1.1	3.2 ± 1.5	13.9 ± 1.5
Sorghum	UW	279.0 ± 8.2	26.0 ± 3.6	46.0 ± 3.6	8.0 ± 1.2	0	1.0 ± 0.4	4.1 ± 0.4
	SW	401.8 ± 10.2	73.5 ± 7.1	68.7 ± 4.2	12.7 ± 0.3	14.9 ± 2.1	2.7 ± 1.4	14.8 ± 0.4
Bean	UW	206.0 ± 12.1	55.7 ± 4.2	22.0 ± 4.1	9.2 ± 0.8	0	0.2 ± 0.1	0.1 ± 0.0
	SW	282.1 ± 15.1	65.0 ± 4.1	52.8 ± 2.6	15.5 ± 1.1	3.4 ± 0.8	7.3 ± 1.4	12.55 ± 1.2
Clover	UW	130.0 ± 12.5	22.0 ± 2.3	46.0 ± 5.0	11.0 ± 2.3	0	0.1 ± 0.1	0.1 ± 0.0
	SW	208.0 ± 10.3	59.7 ± 6.1	63.3 ± 3.6	10.3 ± 2.1	3.8 ± 0.5	7.9 ± 1.4	6.3 ± 0.9
Squash	UW	120.0 ± 10.1	28.0 ± 3.9	30.0 ± 5.1	8.0 ± 0.6	0	1.0 ± 0.3	3.1 ± 0.7
	SW	210.8 ± 12.1	65.7 ± 7.1	42.7 ± 3.5	15.5 ± 0.6	6.5 ± 0.5	6.2 ± 1.2	9.3 ± 1.3
Onion	UW	17.0 ± 2.5	29.0 ± 4.3	54.0 ± 3.4	16.0 ± 3.2	0	0.1 ± 0.0	2.0 ± 0.5
	SW	201.5 ± 14.1	38.3 ± 4.1	76.2 ± 5.1	9.8 ± 2.1	6.4 ± 1.2	2.6 ± 0.2	14.7 ± 0.7
Garlic	UW	122.0 ± 12.0	18.0 ± 2.6	35.0 ± 2.1	7.0 ± 2.5	0	1.1 ± 0.3	1.8 ± 0.6
	SW	234.7 ± 21.5	30.7 ± 5.1	41.0 ± 6.3	11.2 ± 2.1	9.0 ± 2.1	3.3 ± 0.3	13.9 ± 1.2

Values are means (n=18) ± SE

Concentrations of heavy metals varied widely between the field crops at each site and compared to those grown at the other locations.

In the SW, or UW irrigated soils, among the studied crops sorghum and corn seem to contain highest concentrations of heavy metals.

Among the crops under investigation, highest concentrations of Fe, Mn and Cu were obtained in the shoots of sorghum. The dominant cations in corn plants were Zn and Cu followed by Fe and Cu, whereas in clover plants the dominant cation was Ni. Compared to other crops, concentrations of Fe, Mn, Cd and Pb were the lowest in clover.

The variation in the heavy metal concentrations between the collected field crops (cereal and legumes) reflects the differences in uptake capabilities and their further translocation to the edible portion of the plants. Similar results were reported by Anita Singh *et al*. (2010).

The variations in heavy metal concentrations between the crops under investigation at the same site may be ascribed to the differences in their morphology and physiology for heavy metal uptake, exclusion, accumulation and retention (Cariton-Smith & Davis, 1983, Kumar *et al*., 1995 and Singh, 2010). The variations in the element concentration may also depend on soil type, element under study, the type of irrigation water, soil, pH and O.M. % in soil (Dahdoh *et al*., 2005 and El-Sawaf, 2005).

The plants grown on the soil irrigated with SW contained higher concentrations of heavy metals than that grown in soils irrigated with UW. The use of sewage wastewater in crop irrigation at the all 6 sites increased the uptake and accumulations of heavy metals in the plants. The concentrations observed in this study were higher than those reported by other workers (Abdellah, 1995, Adhikari *et al*., 2004 and Kawatra & Bakhetia, 2008) who have examined vegetation from heavy-metals contaminated sites.

Concentrations of Fe, Mn, Zn and Cu in the studied crops are within the acceptable limits for plant growth as well as consumption by humans and animals.

Data obtained reveal that in the SW-irrigated soils, all crops contained concentrations of heavy metals above the permissible levels for consumption by humans, or animals (Abdala and Chmtelnicka, 1990).

Adhikari *et al*. (2004) and Preeti & Fazal (2013) stated that the use of untreated wastewater for irrigation has increased the concentration of Cd and Pb. The main cause of concern in terms of soil contamination with heavy metals in the areas near Assiut City relates to lead (Pb). Lead is a toxic element that can be harmful to plants, although plants usually show ability to accumulate large amounts of Pb without visible changes in their appearance or yield. In many plants, Pb accumulation can exceed several hundred times the threshold of maximum level permissible for human (Wierzhicka, 1995). The introduction of Pb into the food chain may affect human health and thus, studies concerning Pb accumulation in vegetables have increasing importance (Coutate, 1992). The maximum Pb limit for human and animal health has been established for edible parts of crops in china as 0.2 mg kg^{-1} plant (Codex, 2001), and by WHO as 0.3 mg kg^{-1} plant (Bilos *et al*., 2001). In this study, Pb concentration in the shoots was found in the range 1.8-3.1 mg in the UW irrigated soils and 9.3-14.7 mg kg^{-1} dry matter in the SW treated soils, which establishes a critical threat for consumers.

The high Pb concentration in the vegetables treated with UW could result from contamination of the underground water with Pb and other elements due to the run-off of sewage water in this area over 45-50 years, or use of sewage effluents as fertilizers (confirmed by most farmers). On the whole, all vegetables investigated in this study are contaminated with Pb.

Data in Table 2 show that Cd concentration is present at high concentration in the shoots of squash, onion and garlic, and were in the order: Garlic > Squash = Onion. WHO standards for Cd in vegetables stated 0.1 mg kg^{-1} dry matter as the maximum allowable concentration in foods (Codex, 1994 and 2001).

TABLE 2. Transfer factor (TF) of Fe, Mn, Zn, Cu, Cd, Ni and Pb for squash, onion and garlic grown in soils irrigated with sewage water (SW), or underground water (UW) .

Crop	Site	Transfer factor of metals						
		Fe	Mn	Zn	Cu	Cd	Ni	Pb
Wheat	El-Madabegh	5.78	0.31	29.53	2.15	5.92	1.77	3.87
	Mankabad	7.34	0.67	2.37	0.92	1.97	0.45	1.77
	Ellwan	3.74	0.25	1.56	0.69	0.51	0.41	0.89
	Bani Hussein	2.70	0.16	2.62	2.75	8.78	0.63	6.38
	Bani Ghalleb	1.92	0.08	3.33	0.97	9.23	2.38	1.62
	Gahdam	9.53	0.17	23.3	3.17	5.00	1.67	1.33
	UW	9.43	0.52	144.0	4.38	10.0	5.09	10.83
Corn	El-Madabegh	9.19	0.28	49.54	2.46	3.81	1.79	2.45
	Mankabad	12.22	0.28	1.46	1.29	1.48	0.27	0.62
	Ellwan	8.34	0.27	3.51	0.63	0.51	1.44	0.65
	Bani Hussein	5.19	0.15	6.99	3.00	2.61	0.44	5.53
	Bani Ghalleb	4.71	0.09	14.81	3.55	0.78	3.17	1.10
	Gahdam	12.64	0.32	84.44	3.17	10.0	4.29	0.56
	UW	12.10	0.56	186.0	3.13	7.5	1.10	6.25
Sorghum	El-Madabegh	9.24	0.35	45.48	2.80	27.03	0.59	2.91
	Mankabad	10.54	0.24	1.61	0.92	4.20	1.31	0.38
	Ellwan	8.38	0.53	3.25	0.88	6.72	0.21	0.70
	Bani Hussein	7.0	0.15	5.33	4.50	5.74	0.41	6.38
	Bani Ghalleb	4.94	0.16	16.67	4.19	14.0	0.40	2.16
	Gahdam	13.14	0.50	70.0	3.17	91.5	0.47	2.44
	UW	11.46	0.49	176.0	3.13	40.0	0.73	5.42
Bean	El-Madabegh	6.87	0.29	21.13	4.70	3.03	1.67	3.88
	Mankabad	7.39	0.34	2.26	0.69	0.95	0.62	0.59
	Ellwan	6.26	0.33	2.82	0.44	1.64	0.95	0.60
	Bani Hussein	6.47	0.23	7.34	2.00	2.09	0.20	5.53
	Bani Ghalleb	1.22	0.12	8.33	3.87	4.77	4.16	2.06
	Gahdam	10.3	0.32	20.0	3.81	5.00	1.90	7.78
	UW	9.59	0.38	86.0	6.56	3.75	2.17	6.67
Clover	El-Madabegh	4.88	0.25	37.13	2.40	3.81	1.77	2.51
	Mankabad	5.15	0.31	3.21	0.67	1.48	0.27	0.63
	Ellwan	4.85	0.32	3.73	0.69	0.51	1.44	0.86
	Bani Hussein	4.10	0.19	3.32	2.00	2.61	0.41	5.65
	Bani Ghalleb	1.90	0.10	6.11	1.61	0.77	3.17	1.08
	Gahdam	6.35	0.76	24.4	2.22	10.0	4.29	0.56
	UW	6.73	0.31	182.0	7.19	7.5	1.10	6.25

TABLE 3.Cont.

Crop	Site	Transfer factor of metals						
		Fe	Mn	Zn	Cu	Cd	Ni	Pb
Squash	El-Madabegh	17.83	8.24	15.38	8.59	0.00	1.43	0.20
	Mankabad	4.20	0.28	2.95	1.01	4.10	1.32	0.48
	Ellwan	3.62	0.15	7.86	3.50	2.26	1.27	3.40
	Bani Hussein	2.11	0.07	9.26	4.52	4.0	1.07	0.71
	Bani Ghalleb	5.52	0.23	46.67	4.76	30.0	1.45	1.02
	Gahdam	6.67	0.38	164.0	6.91	12.63	2.62	7.58
	UW	15.40	3.92	19.58	6.25	0.0	4.76	6.08
Onion	El-Madabegh	4.90	0.51	1.53	0.84	1.74	0.56	0.29
	Mankabad	2.67	0.28	1.78	0.76	6.67	0.0	1.06
	Ellwan	3.53	0.11	2.10	1.25	1.30	0.41	5.53
	Bani Hussein	1.63	0.12	7.03	3.23	4.0	0.61	1.19
	Bani Ghalleb	6.05	0.40	45.6	3.49	36.0	1.00	1.59
	Gahdam	9.40	0.38	90.0	3.44	7.5	1.20	11.13
	UW	23.32	9.93	20.28	12.5	0.0	0.48	0.83
Garlic	El-Madabegh	6.57	0.27	1.02	0.67	0.59	0.38	0.60
	Mankabad	5.05	0.25	1.21	0.88	7.85	0.64	0.81
	Ellwan	3.97	0.12	3.14	2.0	2.26	0.41	5.11
	Bani Hussein	3.70	0.11	4.81	3.87	4.31	1.68	1.59
	Bani Ghalleb	2.42	0.22	31.1	3.17	90.0	0.0	1.67
	Gahdam	9.21	0.26	76.0	4.69	10.38	0.76	7.58
	UW	16.74	4.58	12.59	5.47	0.0	5.23	3.53

Data of Fazeli (1998) and Shariati & Farshi (1997) were in line with the results of this study. The concentration of Cd in the studied crops grown on soils irrigated with sewage water was several times the permissible levels allowed by WHO for squash, onion and garlic (Chaney, 1993). No Cd was found in the plants grown in soils treated with UW which may result from chemical interactions in the rhizosphere, or in the root cortex (Sanita and Gabbrielli, 1999).

The order of elemental concentration from high to low in the plant shoots is as follows:
Fe: sorghum> corn> bean> clover> squash> garlic> wheat> onion
Mn: Squash> clover= sorghum= onion> wheat> garlic= corn
Zn: squash> corn> onion> sorghum> garlic> clover> wheat= bean
Cu: squash> sorghum> garlic= bean> corn> onion> clover= wheat
Cd: sorghum> garlic> squash> onion> wheat> corn= clover> bean
Ni: corn= clover> squash= bean> wheat> onion= garlic> sorghum
Pb: onion= bean> garlic> sorghum> squash> clover= corn> wheat.

Heavy metal transfer from soils to food crops

Transfer factor (TF) is the ratio of metal concentration in plants to soil DTPA-extractable metal. The soil-to-plant transfer factor is one of the key components of human exposure to metals through the food chain.

Table 2 presents the transfer factor (TF) of the studied elements for squash, garlic and onion in the soils treated with SW and UW. TF varied considerably among the crops and locations.

Based on the TF, the relative efficiency of plants to absorb metals from sewage irrigated soil could be arranged in the following order: for Cd: garlic > squash > onion, for Pb: onion > garlic > squash, for Ni: quash > garlic > onion, for Zn: squash > onion > garlic, for Cu: squash > garlic > onion, for Fe: garlic > squash > onion and for Mn: onion > squash = garlic.

Data indicate that the lowest transfer factor's value is for Mn in the three crops and the highest transfer values are for Cd, Zn and Cu which indicate the accumulation level of the respective metals in the vegetable crops, squash, onion and garlic.

Data also indicate that the TF of Fe, Mn, Zn, Cu, Ni and Pb for the SW-irrigated vegetables is lower than that irrigated with UW. This indicates that uptake of metals by plants does not increase linearly with increasing concentrations of metal in soil (Rattan *et al*., 2005).

The apparent advantage of this phenomenon is that although the long-term sewage irrigation resulted in elevation of metals concentration in soil, this trend is proportionately transferred to food chain.

This information is useful in selecting the suitable crops to be grown on metal-contaminated soils.

Conclusion

The studied crops accumulate metals (heavy metals and micronutrients) in the plant shoot. Thus, plant shoot can be recommended as an indicator for determination of pollution levels of the environment.

The contents of metals in examined plants (grasses, mosses, pine needles) were lower than permitted concentrations, except lead in grasses and mosses. Generally, the concentration of metals decreased with increasing distance from the pollutant emission sources.

Grasses do absorb the contaminants during their relatively short vegetation period, *i.e.* spring-autumn. The concentrations of heavy metals in grasses were proportional to those in soil. For that reason they are very good instruments - biosensors - for observation of the trends in soil composition of pollutants.

The results of investigation were optimization of sampling methods for biological samples and determination methods for xenobiotics in soil and plants. Application of the established sampling procedures and determination methods for xenobiotics in environmental samples can be successfully applied for the purpose of routine analyses in biomonitoring.

This result will serve as a pilot study for further investigation of plant species in bioindication of environmental pollution. We will continue this trend of investigations in our future work.

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References

Abdala, M. and Chmtelnicka, J. (1990) New aspects on the distribution and metabolism of essential trace elements after dietary exposure to toxic metals. *Biot. Trace Elements Res.* **23**, 25-53.

Abdellah, H.A. (1995) Chemical studies on the effect of irrigation by polluted water on some Egyptian soils. *Ph.D. Thesis,* Fac. of Agric., Cairo Univ., Egypt.

Adhikari, T., Manna, M.C. Singh M.V., and Warjari, R.H. (2004) Bioremediation measure to minimize heavy metals accumulation in soils and crops irrigated with city effluent food. *Agric. Environ.* **2**, 266-270.

Ahmed, T. and Al-Hajri, H.H. (2009) Effects of treated municipal wastewater and sea water irrigation soil and plant characteristics. *Int. J. Environ. Res.* **3**, 503-510.

Arora, M., Bala, K. Rani, S., Kaur, A. and Mittal, N. (2008) Heavy metal accumulation in vegetables irrigated with effluent water sources. *Plant Chem.* **111**, 811-815.

Baker, D.E. and Amacher, M.C. (1982) Nickel copper, zinc and cadmium. In: *"Methods of Soil Analysis",* Vol. 2 Page. A.L., Miller R.H., Keeney. D.R., (Ed.) pp. 323-336. American Society of Agronomy, Madison.

Bilos, C., Colombo, J.C. ,Korupka, C.N.S. and Rodriguez M.J. (2001) Source distribution and variability of airborne trace elements in La Plato City area. *Argentina. Environ. Poll.* **111**, 124-132.

Chaney, R.L. (1993) Risks associated with the use of sewage sludge in agriculture. In: *Proc. 15th Federal Convention Australian Water and Waste Water Association.* Vol. 1 p. 7-31.

Chapman, H.D. and Pratt, P.F. (1961) *"Methods of Analysis for Soil, Plant and Water",* Univ. Califor., USA.

Chiroma, T.M., Hymore, F.K. and Ebawele, R.O. (2003) Heavy metal contamination of vegetables and soils irrigated with sewage water in Yola. *NJERD,* **2**, (3).

Codex Alimentarious Commission (FAO, WHO) (2001) Food additives and contaminations. Joint FAO/WHO Food Standards Program 2001: Alinorm 01/12A: 1-289.

Codex Alimentarious Commission CX/FAO 95/19 (1994). Position Paper on Cadmium. **27**, 03, 1998).

Coutate, T.P. (1992) *"Food. The Chemistry of its Components".* 2nd ed. Cambridge Royal Soc. Chems.

Elgharably, A., Abdel Mageed, A. and Elgharably, G. (2014) Status of heavy metals in soils of Assiut as affected by the long-term use of sewage water in crop irrigation: case study. *Egypt. J. Soil Sci.***54,** No.4,pp.289-304.

Ellen, G., Loon, J.W. and Tolsma, K. (1990) Heavy metals in vegetables grown in the Netherlands and in domestic and imported fruits. *Z Lebensm Unters Forsch,* **190**, 34-39.

Fazeli, M.S. (1998) Enrichment of heavy metal in paddy crops irrigated by paper mill effluents near Nanjanud. Mysore. District. Karnatuke. *India Environ. Geo.* **34**, 42-54.

Gholamali, A., Dadresan, M., Khazaei, F. and Khandan, A. (2012) Effect of irrigation with urban sewage and aqueduct water on heavy metals accumulation and nutritional value of Bean (*Phaeolus vulgaris* L.). *ARPN J. Agric. Biol. Sci.* **7**, 168-169

Gomaa, H. (2001) Assessment and evaluation of certain heavy metals in soils and plants in Assiut Governorate. *Ph.D. Thesis,* Univ. of Assiut, Egypt.

Kamel, S. (2008) Extractability and availability of some nutrients in contaminated soils of Assiut. *M.Sc. Thesis,* Univ. Assiut, Egypt.

Kabata-Pendias, A. and Pendias, H. (1992) *"Trace Element in Soils and Plants".* CRC Press Boca Raton, Florida, USA.

Kawatra, B.I., and Bakhetia, P. (2008) Consumption of heavy metals and minerals by adult women through food in sewage and tube well irrigated area around Ludhiana city (Punjab, India). *J. Human Ecol.* **23**, 351-354.

Kumar, P.B., Dushenkov, A.N., Motto, H. and Reskin, I. (1995) Phytoextraction the use of plants to remove heavy metals from soils. *Environ. Sci. Tech.* **29**, 1232-1238.

Lindsay, W.L. and Norvell, W.A. (1978) Development of DTPA soil test for Zn, Fe, Mn and Cu. *Soil Sci. Soc. Am. J.* **42**, 421-428.

Mapanda, F., Mangwayana, E.N. Nyamangara, J. and Giller, K.E. (2005) The effect of long-term irrigation with wastewater on heavy metal contents of soils under vegetables in Harare, Zimbabwe. *Agric. Ecosys. Environ*. **107**, 151-165.

McGrath, S.P., Shen Z.G., and Zhao, F.J. (1997) Heavy metals uptake and chemical changes in the rhizosphere of Thla… spi. caerulescens and Thlaspi achroleucum grown in contaminated soils. *Plant Soil*, **188**, 153-160.

Elsawaf, Nadia (2005) Response of sorghum spp. to sewage waste-water irrigation. *Int. J. Agri. Biol.* **7**, 869-874.

Nrgholi, B. (2007) Investigation of the Firozabad waste water quality-quantity variation for agricultural use. Final report. Iranian Agril. Eng. Res. Institute .

Okoronkwo, I.J. and Onwuchekwa, E.C. (2005) Risk and health implications of polluted soils for crop production. *African J. Biotech.* **4**, 1521-1524.

Preeti, P. and Fazal, M. (2013) Study of heavy metal accumulation in sewage irrigated vegetables in different regions of Agra District, India. *Open J. Soil Sci.* **3**, 1-8. 2013.

Rattan, R.K., Datta, S.P., Chhonkar, P.K., Suribabu, K. and Singh, A.K. (2005) Long-term impact of irrigation with sewage effluents on heavy metal contents in soils, crops and groundwater: a case study. *Agric. Ecosys. Environ.* **109**, 310-322.

Sanitadi Toppi and Gabbreilli, R. (1999) Response to cadmium in higher plants. *J. Environ. and Exp. Bot.,* **41**, 105-130.

Shariati, M. and Farshi, S. (1997) Heavy metal accumulation South Tehran vegetable crops. *J. Soil Water*, **5**, 3.

Sing, K.P., Mohon, D., Sinha, S. and Dalwani, R. (2004) Impact assessment of treated/untreated waste water toxicants discharge by sewage treatment plants and health. Agricultural and environmental quality in waste water disposal area. *Chem.* **55**, 227-255.

Smith, C.J., Hopmans, P. and Cook, F.J. (1996) Accumulation of Cr, Pb, Cu, Ni, Zn and Cd in soil following irrigation with untreated urban effluents in Aust. *Environ Poll.* **94**, 317-323.

Wierzhicka, M. (1995) How lead loses its toxicity to plants. *Acta. Soc. Bot.* **64**, 81-90.

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امتصاص العناصر الثقيلة بالمحاصيل المختلفة فى أراضى تروى بمياه الصرف الصحى فى محافظة أسيوط: دراسة حالة

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تراكم العناصر الثقيلة فى الأراضى الزراعية لا يؤدى فقط الى تلوث البيئة ولكن بل أيضا يؤدى الى التأثير السلبى على صحة الأنسان والحيوان نتيجة التغذية على المحاصيل النامية فى هذه الأراضى.

تهدف هذه الدراسة الى قياس تركيزات عناصر الرصاص والنيكل والكادميوم والحديد والمنجنيز والزنك والنحاس فى نباتات القمح والذرة والذرة الرفيعة والفول والبصل والثوم والبرسيم والكوسة المزروعة فى بعض أراضى محافظة أسيوط فى منطقة عرب المدابغ – منقباد – علوان – بنى حسين – بنى غالب – جحدم ويتم ريها بمياه الصرف الصحى الغير معالج منذ ما يقرب من 40 - 50 عام.

وقد اتضح من هذه الدراسه أن تركيزات الزنك والنحاس والنيكل والرصاص مرتفعة نسبيا فى جميع النباتات التى تروى بمياه الصرف الصحى مقارنة بتلك التى تروى بمياه الأبار الجوفية. وتشير هذه الدراسة الى الأخطار الصحية للأنسان والحيوان والتى قد تحدث نتيجة التغذية على المحاصيل المروية بمياه الصرف الصحى.

وبناءا على النتائج المتحصل عليها يوصى بمعالجة الأراضى الملوثة بالعناصر الثقيلة فى هذه المناطق فى محافظة أسيوط قبل زراعة المحاصيل المختلفة. كما أنه يوصى بعدم زراعة البصل والكوسة والذرة نظرا لتلوث التربة بعناصر الرصاص والنيكل والكادميوم والزنك والنحاس ولكن يمكن زراعة القمح نظرا لعدم امتصاصه لهذه العناصر بتركيزات مرتفعة.