J. Agric. Sci. Mansoura Univ., 34 (5): 5763 - 5772, 2009

IMPACT OF IRRIGATION WITH DIFFERENT WATER QUALITIES ON SOME HEAVY METALS ACCUMULATION IN SOIL AND PLANTS GROWN THEREON.

El-Sayed, M. H.; S. A. El-Tohamy and M. M. El-Kholy
Soils, Water and Environ. Res. Inst., Agric. Res. Center, Giza, Egypt.

ABSTRACT

The aim of this study is to assess the extent of heavy metals contamination in soil and plants grown thereon (i.e., bean. clover, cotton and swiss chard) due to irrigation with different qualities of water. Therefore, soil, water and plant samples were taken from the investigated area, which located Eastern the Nile Delta, South Manzala lake and West canal of Suez. Soils of this area are, generally, irrigated with mixed water from El-Salam canal except for a small area that is irrigated with wastewater from Bahr El-Bakar drain. Results obtained showed that total concentrations of Zn, Cu, Ni, Pb, Cd. As and Se in the mixed water of El-Salam canal and wastewater of Bahr El Bakar drain were greatly less than the maximum levels allowed for irrigation .The sequence of irrigation water sources according to their contamination with heavy metals was El-Salam canal-2 water (1 El-Salam canal -1: 1 drainage water)> El-Salam canal-1 (7 Nile water: 1 drainage water) > Bahr El-Bakar drain water. Total concentrations of Zn, Cu, Pb, Cd, Ni and Se in the surface layer of studied soils ranged from 73.9 to 80.4, 50.8 to 55.1, 26.5 to 41.1, 0.66 to 1.5, 53.8 to 60.8 and 2.23 to 6.0 mg kg^{-1}, respectively; whereas As was not found in a detectable concentration. Also, concentrations of the DTPA-extractable Zn, Cu, Pb, Cd and Se ranged from 0.82 to 1.25, 3.6 to 5.85, 0.53 to 0.82, 0.006 to 0.015 and 0. 043 to 0.12 mg kg^{-1} soil, respectively. Whereas Ni and As were not found in detectable concentrations. Total accumulations of the concerned heavy metals in the soils were less than the maximum permissible loadings according to USEPA-503 regulations. Total content of Zn, Cu, Se, Pb and As in shoots and roots of the grown plants were, to a great extent, in the normal range. However total content of both Cd and Ni were slightly higher. Generally, the sequence of heavy metals in the studied plant shoots and roots according to their concentrations was as follows: Zn≥ Cu> Ni> Pb> Se> Cd>As. Total concentrations of Zn, Cu, and Ni in all plant shoots were mostly higher than in roots; whereas concentrations of As and Se in both shoots and roots were, more or less, the same. On the other hand, total contents of Pb and Cd in the roots were higher than in shoots.
Keywords: Heavy metals, soil, irrigation mixed water, wastewater and plant.

INTRODUCTION

Heavy metals pollution in air-water-plant systems is of major environmental concern on world scale. Heavy metals may enter the ecological environment through anthropogenic activities, such as mining, smelting, sewage sludge disposal, application of pesticides and inorganic fertilizers and atmospheric deposition (Alloway, 1995 and Wang and Stuanes, 2003). Some heavy metals are important for proper functioning of biological systems and their deficiency or excess could lead to a number of disorders; however, some others are toxic even at a very minute concentration. Food chain contamination by heavy metals has became a burning issue in recent years because of their potential accumulation in bio systems through contaminated water, soil and air (Lokeshwari and Chandrappa, 2006). Therefore, a better understanding of heavy metal sources, their accumulation in the soil and the effect of their presence in water and soil on plant systems seemed to be particularly important issues of present-day research on risk assessments. A major part of heavy metals is taken up by crops from the soil via roots. Heavy metals transportation from the soil to the roots largely depends on the type and genetic features of soil forming rocks, granuliometric soil composition, amount of organic mater, pH of the soil, sorption capacity, and amount of $CaCO_3$, mineral oxides, anthropogenic load and other chemical and physical properties of the soil (Cataldo and Wildung, 1978 and Lokeshwari and Chandrappa, 2006).

In the last decades, the reuse of water or low quality water became a part of the extension program for maximizing the use of water resources. However, the uncontrolled application of such waters must have many unfavorable effects on both soils and plants grown especially on the long-term use. The hazard effects are mainly related to the soil properties and water quality, beside the types of growing crops (Elgala et al., 2003).

Therefore, the present study has been undertaken to (i) assess the extent of heavy metals contamination in different qualities of irrigation water (ii) investigate the accumulation of seven heavy metals in the grown plants in order to establish advice regarding consumption of vegetable grown on these contaminated soils (iii) know the availability of metals to plants and their accumulation in the food chain and also to quantify the impact of heavy metals on the vegetation irrigated with El-Salam canal water or Bahr El-Bakar drain water.

MATERIALS AND METHODS

Study area;

The study area is located east of the Nile Delta, south Manzala Lake and west canal of Suez. It is a new reclaimed area, flat spreads across an area of about 130,000 feddan and lies between latitudes 30º 55- and 31º 10- N and longitude 32º 00- and 32º 17- E. It is irrigated from El-Salam canal, except for four sites irrigated with water of Bahr El-Bakar drain. El-Salam canal water is a mixture of the Nile and drainage waters at a ratio of 7 Nile water: 1 drainage water from El-Serw agricultural drain (El-Salam canal-1) and this water is being used in irrigation of El-Mataria area; El-Salam canal-1 water is mixed thereafter with Hadoos drain water with mixing rate 1:1 (El-Salam canal-2) to irrigate the soils of the rest area.

Sampling:

Sampling had been carried out for a year from May 2007 to May 2008. Water samples (1L) were taken once in three months from two sites along El-Salam canal (at the beginning from El-Salam canal-1 nearby El-Mataria area and at the middle from El-Salam canal-2 as mentioned above), and from two sites close to Bahr El-Bakar drain before and after shader Azzam point. For heavy metals determination, subsamples (500 ml) were preserved with 2 ml nitric acid to prevent precipitation and adhesion of metals on the bottle walls (APHA, AWWA and WPCF, 1998).

Soil surface samples (0-30) were collected from twelve sites where the plants were sampled (Fig 1).These sites are divided into three groups irrigated with different water qualities as follows; group No.1 (El-Mataria) irrigated with El-Salam canal-1 water (7:1), group No.2 (10th of Ramadan, Khaled Ebn El-Waleed, El-Rowaad, El-Esraa, El –Nasr and El-Zohor, Bahry Naser and 6th of October soldiers) irrigated with El-Salam canal-2 water (1:1) and group No.3 (Tarek Ebn Zeiad, El-Salah, El-Ekhlass and El-Hammareen) irrigated from Bahr El-Bakar drain. The samples were air dried, ground, sieved using 1.0 mm sieve and were kept in plastic bottles for analysis. Well-mixed samples of 2g each were taken in 250 ml digestion tubes, digested with 10 ml aqua regia (7.5 ml conc. HCl:2.5 ml conc. HNO_3) in digestion unit, filtered using whatman paper No. 40 and and were diluted to 50 ml with distilled water (Cottenie et al., 1982).

Faba bean, clover, cotton and Swiss chard plants grown on the aforementioned twelve sites were sampled. The plant samples were thoroughly washed to remove all adhered soil particles, cut into shoots and roots, air-dried for 2 days, oven dried at 70^o C over night, ground and kept in plastic bottles for analysis. Digestion of the samples (1.0g each) was carried out using 10 ml of aqua regia according to Cottenie et al. (1982).

Analysis:

Electrical conductivity (EC), pH, cations and anions of the water samples and soil paste saturated extracts were carried out according to APHA, AWWA and WPCF, (1998) and Black, (1965), and were presented in Tables (1) and (2), respectively. Some physical properties of the soil samples (texture, $CaCO_3$ and organic matter (O.M) were determined according to Black (1965) and presented in Table (3). Total heavy metals concentration in each of the water, soil and plant were analyzed using an Inductively- Coupled Plasma Atomic Emission Spectrometer (ICP), (Plasma JY Ultima).

Table (1): Average values of some chemical properties of the irrigation waters used in the studied areas

No.	Source of irrigation water	pH	EC (dSm^{-1})	Soluble ions ($mmol_c\ dm^{-3}$)							
				Cations				Anions			
				Na^+	K^+	Ca^{2+}	Mg^{2+}	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}
1	El-Salam canal-1(7:1)	7.63	0.77	2.30	0.28	2.60	2.80	0.0	4.80	1.50	1.68
2	El-Salam canal-2(1:1)	7.33	1.29	5.60	0.37	3.40	3.90	0.0	4.20	3.20	5.87
3	Bahr El-Bakar drain	7.31	3.80	23.0	0.31	7.81	7.25	0.0	4.27	14.90	19.20

Table (2): Some chemical characteristics of the studied soils

Source of irrigation water	Site	pH	EC (dSm^{-1})	Soluble ions ($mmol_c\ dm^{-3}$)							
				Cations				Anions			
				Na^+	K^+	Ca^{2+}	Mg^{2+}	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}
El-Salam canal-1(7:1)	**El-MATARIA**	7.66	2.80	14.1	0.30	8.24	5.70	0.0	4.42	4.62	19.3
El-Salam canal-2(1:1)	**El-Rowaad**	7.88	8.83	82.3	1.20	17.0	8.10	0.0	2.40	49.9	56.3
	Kaled Ebn El-Waleed	7.82	10.5	39.4	1.30	48.7	39.0	0.0	1.70	52.2	74.5
	El-Esraa	7.66	3.48	18.1	0.66	9.50	9.54	0.0	9.00	17.7	11.1
	El-Nasr and ElZohor	7.53	2.91	18.8	0.86	6.36	3.18	0.0	8.00	14.8	6.40
	Bahry Naser	7.67	7.48	48.3	1.10	10.0	10.6	0.0	8.00	42.7	19.3
	6th of October soldiers	7.36	14.2	82.2	2.20	25.4	38.2	0.0	9.00	90.9	48.1
	10th of Ramadan	7.83	6.35	43.9	1.10	9.50	14.9	0.0	10.0	37.7	21.7
Bahr El-Bakar drain	**Tarek Ebn Zeiad**	7.74	4.13	23.6	0.40	8.24	9.50	0.0	3.74	18.6	19.4
	El-Salah	7.80	13.2	87.7	1.50	33.6	38.0	0.0	2.40	71.3	87.1
	El-Ekhlass	7.81	6.38	18.2	0.74	35.2	20.0	0.0	2.04	24.4	47.7
	El-Hammareen	7.20	11.4	88.2	1.70	9.50	20.6	0.0	5.00	69.3	45.7

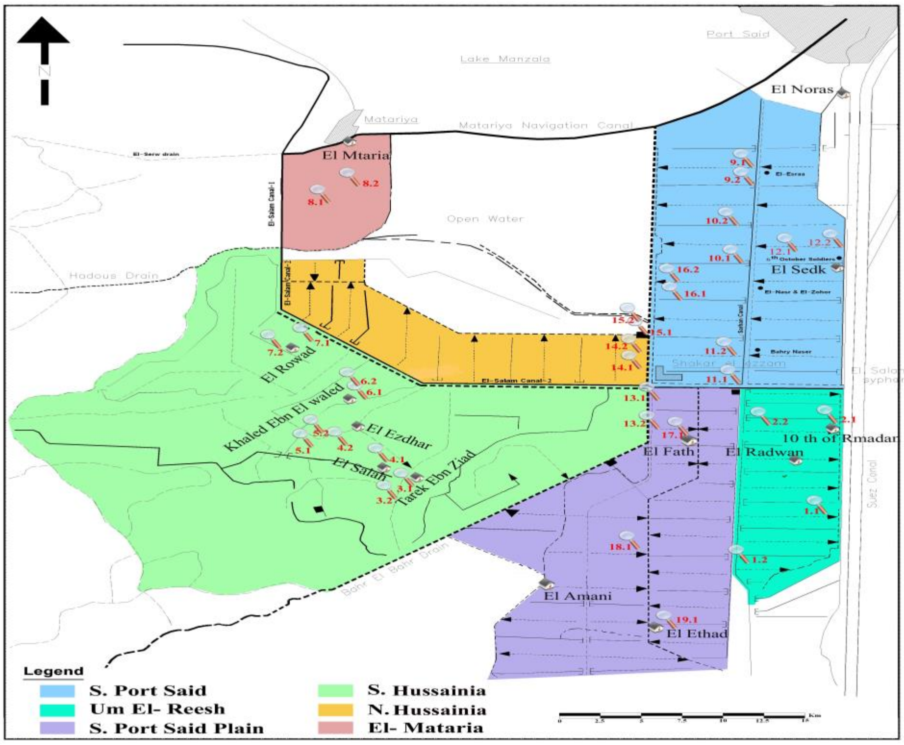

Fig. (1): Map of the study area showing the sampling locations.

Table (3): Some physical characteristics of the studied soils

Source of irrigation water	Site	Organic matter %	CaCO %	Particle size distribution %			Textural class
				Sand	Silt	Clay	
El-Salam canal-1(7:1)	El-MATARIA	0.72	1.10	21.0	51.8	27.2	Silty loam
El-Salam canal-2(1:1)	El-Rowaad	0.71	1.65	41.4	20.0	36.6	Clay loam
	Kaled Ebn ElWaleed	0.56	3.55	14.0	46.0	40.0	Silty clay
	El-Esraa	0.51	2.56	31.5	45.3	23,2	Loam
	El-Nasr and ElZohor	0.65	1.75	16.5	50.4	33,1	Silty clay loam
	Bahry Naser	0.74	1.65	16.8	48.2	35.0	Silty clay loam
	6th of October soldiers	0.56	1.15	28.2	41.2	30.6	Clay loam
	10th of Ramadan	0.61	1.70	32.8	22,6	44.6	Clay
Bahr El-Baker drain	Tarek Ebn Zeiad	0.98	1.62	20.5	45.5	34.0	Clay loam
	El-Salah	0.86	1,24	15.0	25.4	59.6	Clay
	El-Ekhlass	0.93	0.89	40.0	20.5	39.5	Clay loam
	El-Hammareen	0.90	0.95	32.2	30.6	37.2	Clay loam

RESULTS AND DISCUSSION

Heavy metal contents in the used waters:

Average values of heavy metals concentration in El-Salam canal-1(7 Nile water:1 drainage water), El-Salam canal-2 (1 El-Salam canal-1 water : 1 drainage water), and Bahr El- Bakar drain were presented in Table (4). Obtained results showed that concentrations of Zn, Pb, Cu, As, Se, Ni, and Cd in the three sources of irrigation water ranged from 3.3 to 89.7, n.d. to77.0, n.d to 19.2, 3.1 to 8.2, 0.41 to 5.3, n.d to 0.96 and n.d to 0.88 µg dm^{-3}, respectively, and they were less than their permissible maximum concentrations (PMC) in irrigation water according to Ayers and Westcost (1994). Concentrations of these metal ions in El-Salam canal-2 were the highest, but their concentrations in Bahr El-Bakar drain were the lowest ones. These findings could be attributed to the different in mixing ratio between fresh and drainage water in El-Salam canal on one hand, and adsorption and precipitation of these heavy metals on the suspended matter and organic compounds on bed and sides of Bahr El-Bakar drain on the other hand. The sequence of heavy metals according to their concentrations in the studied irrigation waters was, to a great extent, as follows: n>Pb>Cu>As>Se>Ni>Cd.

Table (4): Average values of heavy metals concentration in the irrigation waters used in the studied area

No.	Source of irrigation water	Metal (ug dm^{-3})						
		Zn	Cu	Pb	As	Se	Ni	Cd
1	El-Salam canal-1(7:1)	21.9	5.80	6.70	7.60	1.7	n.d	n.d
2	El-Salam canal-2(1:1)	89.7	19.20	77.0	8.20	5.30	n.d	0.88
3	Bahr El-Bakar drain	3.30	n.d	n.d	3.10	0.41	0.96	n.d
PMC according to Ayer and Westcost (1994)		2000	200	5000	100	20.0	200	10.0

PMC=Permissible Maximum Concentration n.d= not detected

Heavy metal contents in soils irrigated with the used irrigation waters:
Total contents:

Data in Table (5) showed that total contents of Zn, Cu, Pb, Cd, Ni, and Se in the surface layer (0-30 cm) of the investigated soils, in general, ranged from 73.9 to 80.4, 50.8 to 55.1, 26.5 to 41.1, 0.66 to 1.5, 53.8 to 60.8, and 2.23 to 6.0 mg kg^{-1} soil, respectively; whereas As was not detected. The sequence of heavy metals according to their total concentrations in soils was: Zn> Ni> Cu> Pb> Se> Cd> As. Total contents of Zn, Cd, Pb and Se in soils irrigated from El-Salam canal-1 (7:1) were slightly higher than the corresponding ones of the other soils. On the other hand, differences in total concentrations of these metal ions between the soils irrigated with El-Salam canal water and Bahr El-Bakar drain water were, generally, not detected. These findings could be attributed to the lower concentrations of heavy metals in the irrigation water as aforementioned, chemical and physical properties of the soils, downward movement of heavy metals from surface to subsurface layer or ground water with water filtration process and/or their removal from soil by grown plants (Cataldo and Wildung, 1978 and Lokeshwari and Chandrappa, 2006).

Table (5): Average values of total content of heavy metals in the studied soils as affected by source of irrigation water

No.	Source of irrigation water	Metal (mg kg^{-1} soil)						
		Zn	Cu	Pb	As	Se	Ni	Cd
1	El-Salam canal-1(7:1)	80.4	50.8	41.1	n.d	6.00	53.8	1.50
2	El-Salam canal-2(1:1)	73.9	52.5	26.8	n.d	2.27	60.8	0.30
3	Bahr El-Bakar drain	74.8	55.1	26.5	n.d	2.23	60.4	0.66
Maximum permitted loadings in soil (established by USEPA-503 regulations)		1400	750	150	20.5	50	210	19.5

n.d= not detected

Accumulation of these metals in the studied soils still less than the maximum permitted metal loadings in soil (mg kg^{-1}) established by the U. S. Environmental Protection Agency 503 regulations (McBride, 1995).

DTPA-extractable contents:

Results given in Table (6) show values of the DTPA-extractable Zn, Cu, Pb, As, Se, Ni and Cd from the surface soil samples collected from the studied area as a result of irrigation with different water qualities. Concentrations of DTPA-extractable Zn, Cu, Pb, Cd and As ranged from 0.82 to 1.25, 3.6 to 5.85, 0.53 to 0.82, 0.006 to 0.015 and 0.043 to 0.12 mg kg^{-1} soil, respectively; whereas available concentrations of both Ni and As were not detected. Available concentrations of Zn, Cu and Cd in soils irrigated from Bahr El-Bakar drain were slightly higher than the corresponding ones in soils irrigated from El-Salam canal waters. On the other side, concentrations of Pb and Se in soils irrigated with El-Salam canal-1water were the highest as compared with the corresponding ones of the soils irrigated with El-Salam canal-2 water or Bahr El-Bakar drain water. This findings may be due to the differences in soil physical properties, i.e. organic matter content, $CaCO_3$ content and particle size distribution, (Table 3), as well as their different forms in soil; where variable parts of their contents would be bound with the different soil components, i.e. organic matter, carbonates, oxides and /or clay minerals in unsoluble forms (McGrath and Cegarra, 1992, Ma and Rao, 1997 and El-Sayed, 1999).

Table (6): Average values of DTPA- extractable heavy metal contents in the studied soils as affected by source of irrigation water

No.	Source of irrigation water	Metal (mg kg^{-1} soil)						
		Zn	Cu	Pb	As	Se	Ni	Cd
1	El-Salam canal-1(7:1)	0.98	4.13	0.82	n.d	0.120	n.d	0.030
2	El-Salam canal-2(1:1)	0.82	3.60	0.53	n.d	0.043	n.d	0.006
3	Bahr El-Bakar drain	1.25	5.85	0.52	n.d	0.095	n.d	0.015

n.d= not detected

Heavy metal concentrations in the grown plants:

Heavy metal contents in plants depend on their bioavailability in the soil and on the atmospheric deposition, with the former media by sewage irrigation and fertilization, and the latter either directly entering the plants through stomata or taken up by plant roots after their deposition on the soil surface (Alloway, 1995).

Heavy metal total contents in both shoots and roots of faba bean as an edible plant, clover as a fodder crop, cotton as a fiber crop and Swiss chard as a vegetable plant were presented in Figs. (2 and 3). Concentrations of Zn, Cu, Se, Pb and As in shoots and roots of all concerned plants were, to a great extent, in the normal range according to Kabata- Pendias and Pendias (1992). However total contents of Cd and Ni were slightly higher than the normal ones. Accumulation of the concerned elements in the investigated plant shoots and roots were, more or less, similar except for Ni concentration which was lower in cotton plant than in other ones. The sequence of these metals in the plant shoots and roots, in general, was in the following descending order: Zn≥Cu>Ni>Pb>Se≥Cd>As. This behavior of heavy metals in the plant tissues may be attributed to the variations in soil chemical and physical properties, total element content in soil, their chemical fractionation forms, element type and its essential role in plant metabolism, and plant genotype (Cataldo and Wildung, 1978, Kabata Pendias and Pendias, 1992 and Wang and Stuanes, 2003).

F2

F3

Obtained data also declared that, total concentrations of Zn, Cu and Ni in all concerned plant shoots were higher, to a great extent, than the corresponding ones in roots; whereas accumulations of As and Se in the roots were, more or less, similar to those in shoots. On the other hand, total concentrations of both Pb and Cd in the roots were higher than in shoots. These findings may be due to Zn, Cu and, to some extent, Ni are essential elements for plant growth; but Pb and Cd are considered to be non essential elements for plant metabolic processes. Also, Pb and Cd translocation from roots to top may be restricted because they are easily held manly on exchange sites of active compounds located in the cell walls; as well as Cd bounds to sulphur containing proteins to form metabolically inactive complexes which accumulate in roots and reduce Cd movement from roots to leaves (Kabata –Pendiais and Pendias, 1992 and Cieslinski et al., 1996). Data showed also that, the used irrigation water quality was not of an obvious effect on the accumulation of the concerned heavy metals in the grown plant shoots and roots. This finding may be due to the differences in soil chemical and physical characteristics (Tables 2 and 3), element chemical forms in soil and its bioavailability, plant genotype, chemical composition of the used irrigation waters (Table 1) and their little content of heavy metals (Table 4).

Conclusion

The results of this study showed that the used irrigation waters (namely, El-Salam canal water and wastewater of Bahr El-Bakar drain) can not be considered the sole reason of contamination of the investigated soils with Zn, Cu, Ni, Pb, As, Se and Cd because of their concentrations in these waters were less than the permissible maximum concentrations. Therefore, accumulation of these metal ions in soil may be also due to the soil origin (parent material), fertilization, management processes, pesticides used, and atmospheric depositions. Total concentrations of the concerned heavy metals in the grown plant shoots and roots (bean, clover, cotton and Swiss chard) were to a great extent, in the normal range. Total content of Zn, Cu and Ni, opposite to Pb and Cd, in all plant shoots were mostly higher than in roots.

REFERENCES

Alloway, B. J. (ed.) (1995). Heavy Metals In Soils. Blockie Academic & Profiessional Publishers, London, UK. 368pp.

APHA, AWWA and WPCF (1998). Standard Methods for the Examination of Water and Wastewater. Washington, DC., USA.

Ayers, R. S. and D. W. Westcost (1994). Water Quality for Agriculture. Food and Agriculture Organization of the United Nations (FAO). Rome, 29 Rev.1.

Black, C. A. (ed.) (1965). Methods of Soil Analysis. Parts 1 and 2, A Society of Agronomy, Inc. Pub., Madison, Wisconsin, USA.

Cataldo, D. A. and R. E. Wildung (1978). Soil and plant factors influencing the accumulation of heavy metals by plants. Environ. Health Persp., 27:149-159.

Cieslinski, G., H. Neilsen and E. J. Hogue (1996). Effect of soil cadmium application and pH on growth and cadmium accumulation in roots, leaves and fruit of strawberry plants (*Fragaria xanamassa* Duch). Plant and Soil, 180:267-276.

Cottenie, A., M. Varloo, I. Kiekens, G. Velghe and R. Camerlynck (1982). Chemical Analysis of Plants and Soils. Lab of analysis and Agro. State, Unv. Ghent, Belgium.

Elgala, A. M., M. A. O. Elsharawy and M. M. Elbordiny (2003). Impact of sewage water used for irrigation on soil characteristics and heavy metals composition of some grown crops. Egypt. J. Soil Sci., 43:405-419.

El-Sayed, M. H. (1999). Balance of some trace elements in soil and plant under polluted conditions. Ph.D. Thesis, Fac. Agric., Ain Shams Univ., Egypt.

Kabata-Pendias, A. and H. Pendias (1992). Trace elements in soils and plants. 2nd edition. CRC Press Inc., Boca Raton Ann Arbor London,UK.

Lokeshwari, H. and G. T. Chandrappa (2006). Impact of heavy metal contamination of Bellandur Lake on soil and cultivated vegetation. Current Science. 91:622-627.

Ma, L. O. and G. N. Rao (1997). Chemical fractionation of cadmium, copper, nickel and zinc in contaminated soils. J. Environ. Qual., 26:259-264.

McBride, M. B. (1995). Toxic metal accumulation from agricultural use of sludge: are USEPA regulations protective?. J. Environ. Qual., 24:5-18.

McGrath, S. P. and J. Cegarra (1992). Chemical extractability of heavy metals during and after long- term applications of sewage sludge to soil. J. Soil Sci., 43:313-321.

Wang, H. and A. O. Stuanes (2003). Heavy metals pollution in air-water-soil – plant system of Zhuzhou city, Hyman province, China. Water, Air and Soil Pollution. 147: 79-107.

تـأثير الـرى بميـاه مختلفـة الجـودة علـى تـراكم بعـض العناصـر الثقيلـه فـى التربـة والنبـاتات النـامية عليها

مصطفى حلمى السيد ، سيد أحمد التهامى و حمد محسن الخولى
معهد بحوث الاراضى والمياه والبيئة- مركز البحوث الزراعية- الجيزة - مصر

تهدف هذه الدراسة الى تقييم مدى التلوث بالعناصر الثقيلة فى التربة والنبات نتيجة للرى بمياه مختلفة الجودة. ولذلك أخذت عينات تربة ومياه ونبات (فول، برسيم، قطن، سلق) من منطق الدراسة الواقعة شرق دلتا النيل الى جنوب بحيرة المنزلة وغرب قناه السويس والتى تروى بمياه الرى المخلوطة بترعة السلام ما عدا مساحة صغيرة منها تروى بمياه عادمة من مصرف بحر البقر.

ولقد أوضحت النتائج المتحصل عليها الاتى:

- التركيز الكلى لكل من الزنك، النحاس، النيكل، الرصاص، الكادميوم، الارسنك، السلينيوم فى المياه المخلوطة بترعة السلام والمياه العادمة بمصرف بحر البقر اقل بكثيرمن الحدود العليا المسموح بها.
- ترتيب مصادر مياه الرى بالمنطقة تبعا لتلوثها بالعناصر الثقيلة كالاتى:
- مياه ترعة السلام-٢(نسبة خلط ١:١ من ترعة السلام-١ والصرف الزراعى) > مياه ترعة السلام -١ (نسبة خلط ٧: ١ من مياه النيل والصرف الزراعى)> المياه العادمه بمصرف بحر البقر.
- تراوحت التركيزات الكلية لكل من الزنك ، النحاس، الرصاص، الكادميوم، النيكل والسلينيوم فى الطبقات السطحية للاراضى تحت الدراسة من ٧٣,٩ الى ٨٠,٤، ٥٠,٨الى ٥٥,١، ٢٦,٥ الى ٤١,١، ٠,٦٦ الى ١,٥، ٥٣,٨ الى ٦٠,٨و ٢,٢٣ الى ٦,٠ ملليجرام/ كيلوجرام تربة على التوالى.فى حين كان تركيز الارسنك لايمكن قياسة.
- تراوحت ايضا تركيزات الزنك، النحاس، الرصاص، الكادميوم والسلينيوم المستخلصة من التربة بواسطة DTPA من ٠,٨٢ الى ١,٢٥، ٣,٦ الى ٥,٨٥، ٠,٥٣ الى ٠,٨٢، ٠,٠٠٦ الى ٠,٠١٥، ٠,٠٤٣ الى ٠,١٢ ملليجرام/ كجم تربة على التوالى ، فى حين كانت تركيزات كل من النيكل والارسنك قليلة بحيث لايمكن قياسها.
- التراكمات الكلية لتلك العناصر المدروسة فى التربة كانت أقل من الحدود القصوى المسموح بها طبقا لتشريعات وكالة حماية البيئة الامريكية رقم ٥٠٣.
- كان المحتوى الكلى لكل من الزنك، النحاس، السيلينيوم، الرصاص والارسنك فى المجموع الخضرى والجذرى للنباتات النامية لحد كبير فى المدى الطبيعى العادى ، الا أن المحتوى الكلى من الكادميوم والنيكل كان أعلى قليلا.
- بوجه عام كان ترتيب تلك العناصر الثقيله فى المجموع الخضرى والجذرى للنباتات النامية كالاتى: الزنك≤النحاس>النيكل>الرصاص>السيلينيوم≤الكادميوم>الارسنك.
- كانت التركيزات الكلية لكل من الزنك، النحاس والنيكل فى المجموع الخضرى لكل النباتات غالبا أعلى منها فى المجموع الجذرى ، الا ان تركيزات الارسنك والسيلينيوم كانت تقريبا متساوية.
- المحتوى الكلى لكل من الرصاص والكادميوم فى جذور النباتات المعنية بالدراسة كانت أعلى منها فى المجموع الخضرى.