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CASE STUDY

Risk assessment of hazardous impacts on urbanization and industrialization activities based upon toxic substances

T.M. Salem*, Sh.S. Ahmed, M.A. Hamed, G.H. Abd ElAziz

Environmental Department, Soils, Water and Environment Research Institute, Agricultural Research Center, Ministry of Agricultural and Land Reclamation, Giza, 12112, Egypt

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ABSTRACT: A risk assessment study was conducted to predict the expected hazardous influence on the ecosystem resulted from urbanization and industrialization activities at Helwan area, Egypt. To achieve these goals, soils, plants and water samples were collected from Helwan area, and their total concentrations of inorganic contaminants (Cd, Cr, Co, Cu, Fe, Mn, Ni, Pb, and Zn) and organic pollutants; such as Phenol and hydrocarbons were measured. The obtained results showed that, the concentrations of organic contaminants in water streams and surrounding soils recorded high concentration values than the permissible limits, while inorganic elements were within the safe limits for irrigation. In addition, soils irrigated with the effluents of industrial units recorded high values of inorganic and organic contaminants. Consequently, the levels of these contaminants were high in plant tissues grown thereon; especially the edible parts. Risk assessment based on available predicted no effect concentration values for the aquatic and terrestrial environment was performed. Inorganic elements were expected to cause serious hazard problems for both aquatic organisms and soil microorganisms. The impact of these pollutants on human health was calculated using daily metals intake of inorganic metals via consumption of edible plants. Hazard index values proved that concentrations of Cr may cause serious hazard problems for humans in this area; especially, children.

KEYWORDS: *Hazard index; Heavy metals; Organic pollutants; Risk assessment; Risk quotient; Wastewater*

INTRODUCTION

The pressures of an ever-increasing population and industrial development have led to the addition of an array of man-made chemicals in the environment, leading to a tremendous deterioration in environmental quality. The speedy urbanization and industrialization has led to increased disposal of pollutants like heavy metals, radionuclides, and various types of organic and inorganic substances into the environment. Metals dissolve in water and are easily absorbed by fish and other aquatic organisms. Small concentrations (levels) can be toxic because metals undergo bioconcentration, which means that their concentration in an organism is higher than in water (Wright and Welbourn, 2002).Metals can be lethal or harm to the organisms without killing it directly. Adverse effects on an organism's activity, growth, metabolism, and reproduction are examples of sublethal effects (Wright and Welbourn, 2002). Also large areas of land can be contaminated by heavy metals released from smelters, waste incinerators, industrial wastewater, application of sludge or municipal compost pesticides and fertilizers (Abdelhafez and Li, 2015; Karbassi and Pazoki, 2015). Irrespective of their sources in the soil, accumulation

*Corresponding Author Email: *tamersalem43@gmail.com*
Tel.: +2 0114 569 4902; Fax: : +2 572 0608

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of heavy metals can degrade soil quality reduce crop yield and the quality of agricultural products, and thus negatively impact on the ecosystem (Nagajyoti *et al.,* 2010).Soil contaminated with metals is a primary route of toxic element exposure to humans. Toxic metals can enter the human body by consumption of contaminated food crops, water or inhalation of dusts (Cambra *et al.*, 1999). It has been estimated that more than 70% of dietary intake of cadmium is contributed via food chain (Wagner, 1993). Vegetables grown on contaminated land may accumulate toxic metals. Prolonged consumption of contaminated foodstuff may lead to the unceasing accumulation of toxic metals in the liver and kidney of humans, resulting in the disturbance of biochemical processes, such as, liver, kidney, cardiovascular, nervous and bone disorders (WHO, 1992; Jarup, 2003). Helwan city considered as one of the greater industrial area in greater Cairo region. It contains 16.5 % of the total industrial activities in Cairo. It has different industrial activities, i.e. cement, metals and chemicals, which contribute directly to the pollution of the city and poses a potential risk for human health (Yigitcanlar and Dizdaroglu, 2015). It is therefore important to assess contamination from the industries so as to understand their threats to the environment and design appropriate management practices. Thus, the current study was undertaken to determine the concentrations of some inorganic contaminants (Cd, Cr, Co, Cu, Fe, Mn, Ni, Pb and Zn) and organic pollutants (Phenole and hydrocarbons) in soils, plants and water streams collected from Helwan area, Egypt. In addition, the potential risks of these pollutants on aquatic organisms, soil microorganisms and humans lives in the study area were also investigated. This study has been performed in Helwan, Egypt during 2014.

MATERIALS AND METHODS

Experimental site description.

The experimental site covers the area around Helwan district. Helwan is an industrial area at the southern of Cairo (29° 46' N latitude, 31° 14' E longitude) and near from the Nile River (Fig. 1). A lot of industries (Iron and steel, fertilizers and chemicals, cement, blocks….etc) are spread in the study area. Some of

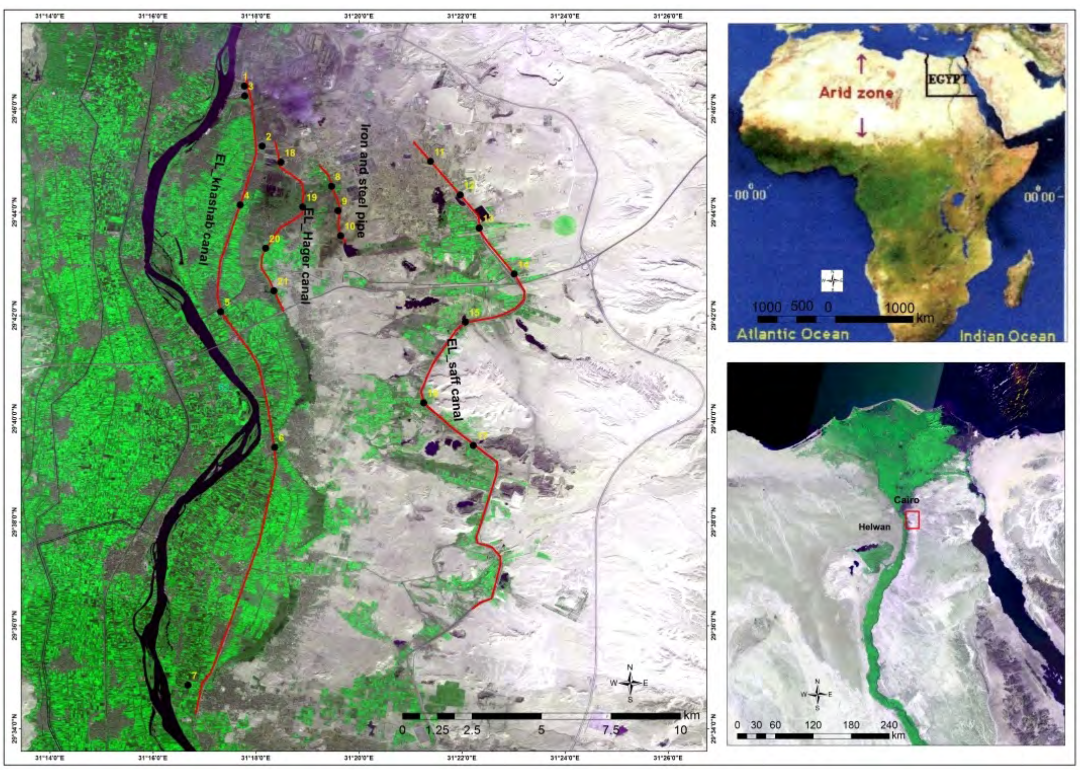

Fig. 1. Map of samples sites and water streams of Helwan area, Egypt

these units are discharges their effluents to the nearest wastewater treatment plant, while most of them are not connected with the sanitation service of the city. Therefore, the effluents of these industries are discharged into the nearest water stream instead of iron and steel unit, which discharge their effluents into special pipe to treat it with evaporation process into lagoons far 5 km from the factory. This pipe also used for irrigation of large areas located in the study area. Helwan has a sewage water treatment unit discharge their effluents (after primary treatment) into El-Saff canal, which used for irrigation. A wide range of soils used for vegetable production in this area, to supply markets in the city.

Site sampling

Surface soil samples (0 – 30 cm) were collected from the agricultural areas and kept in polyethylene bags. Soil samples were air dried and sieved through a <0.2 mm and stored in the labeled polythene sampling bags (Lei *et al.*, 2008). A diversity of edible plants grown in the study area; maize (*Zea Maize*), wheat (*Triticum aestivum L.*) and bean (*Vicia faba*) as cereal crops, cabbage (*Brassica oleracea var. capitata*), malva (*Malva porviflora L.*), potatoes (*Solanum tuberosum*), gumbo (*Bursera simaruba*) and onion (*Allium cepa*) as vegetable crops were collected from different sites of the sampling zone in 3–5 replicates and stored in labeled polythene sampling bags and brought to the laboratory directly after sampling. Edible parts were washed with tap water to remove any kind of deposition like soil particles, then oven dried and ground into powdered form for digestion (Jamali *et al.*, 2009). Water samples were collected from each site (Fig. 1) in pre-cleaned high-density polyethylene bottles. These bottles were rinsed earlier according to the procedure described by Chary *et al.*, (2008). Samples were kept in ice tank, and then stored at 4 °C until analysis.

Trace elements analysis

Three replicate soil samples, each of 1.0 g were taken from each site and digested using 2.5 mL of concentrated nitric acid (60%) and 7.5 mL of hydrochloric acid (aqua regia mixture) (Cottenie *et al.*, 1982).

Plant samples were digested using mixture of sulfuric and perchloric acid (5:1) (Jackson, 1979), while water samples (50 mL) were digested with10 ml of concentrated HNO_3 at 80 ºC until the solution became transparent (APHA, 2005). These transparent solutions were then diluted to 50 mL with deionized water after filtration through a Whatman42 filter paper. The concentrations of Cd, Co, Cu, Cr, Fe, Pb, Mn, Ni and Zn in the filtrate were determined by using inductively coupled plasma (ICP- JY ULTIMA).

Organic compounds determination

Analysis of total hydrocarbons

Water samples were extracted three times with 60 ml of dichloromethane in a separating funnel. Sample extracts were combined and concentrated by rotary evaporation to 5 ml. Finally, the samples were concentrated under a gentle stream of pure nitrogen to a final volume of 1 mL, then measured using a Spectrofluorometer (Spectronic 501) at 410 nm emission after excitation at 360 nm and chrysene as standard (Parsons *et al.,* 1985)

Analysis of total phenol

Concentration of total phenol was determined calorimetrically using the Folin-Ciocalteu Method (Box, 1983). A 1mLof sample solution or standard solution was added to 10 mL of deionized water and 1.0 mL of Folin-Ciocalteu reagent. The mixture was allowed to stand for 5 minutes and then 2.0 mL of sodium carbonate was added to the mixture. The mixture was left in a dark place for an hour; thereafter, absorbance was measured at 750 nm using a spectrophotometer (Spectronic 501) in 1.0 cm quartz cells against Gallic acid as standard.

Risk Assessment of Inorganic Contaminants on the Ecosystem

Risk assessment of heavy metals on the aquatic organisms and soil microorganisms

The methodology used to predict exposure concentrations for various exposure routes is based upon EC (part II, 2003). This document assists authorities in determining the environmental risk assessment of existing and hazard compounds. The risk assessment is based on available Predicted No Effect Concentration (PNEC) values for the aquatic and terrestrial environment. The PNEC values from both the aquatic and terrestrial compartments are mainly adapted from European Union's risk assessment reports.

The environmental risk resulted from contaminants on aquatic organisms was assessed through the calculation of risk quotients (RQ) as described by Eriksen *et al.,* (2009). RQ values for aquatic organisms were calculated from the measured environmental concentration (MEC) in water streams and the predicted no effect concentration (PNEC) of heavy metals under study. Same equation was used to calculate the RQ for soil microorganisms instead of MEC of soil. A commonly used risk ranking criteria was applied: RQ < 0.1 means minimal risk, 0.1 ≤ RQ < 1 means median risk, and RQ≥1 means high risk (Hernando *et al.*, 2006).

Human health risk assessment

To assess the human health risk of heavy metals, it is necessary to calculate the level of human exposure to that metal by tracing the route of exposure of contaminants to human body. Several exposures routes for heavy metals that depend upon contaminated media of soil and/or vegetables on the recipients. Population used to consumes vegetables enriched with higher concentration of heavy metals, which enters their human body leading to a specific health risk (Khan *et al.*, 2008). In the present study vegetables grown on the study area were collected and their metal concentration was used to calculate the health index (HI). Value of HI depends on the daily metal intake of plant and soil through three pathways (Ingestion, dermal and inhalation) divided by their reference dose (Rfd). Rfd is an estimated exposure of metal to the human body that has no hazardous effect during life time (US-EPA 2001).

Exposure assessments

The daily metal intake of trace metals through different pathways was estimated to assess the health risks in the study area according to USEPA (1996; 2001) as Equations 1, 2 and 3:

$$\text{D ing (plant or soil)} = C \times \frac{ingR \times EF \times Ed}{BW \times AT} \times 10^{-6} \quad (1)$$

$$\text{D dermal} = C \times \frac{SL \times SA \times ABS \times EF \times Ed}{BW \times AT} \times 10^{-6}\ \text{D} \quad (2)$$

$$\text{inhalation} = C \times \frac{inhR \times EF \times Ed}{PEF \times BW \times AT} \quad (3)$$

Meanings and values of symbols used in these equations were illustrated in Table 1.

Non-cancer and cancer risk assessments

The obtained results of three pathways of D ing, D dermal and D inh were used to quantify the hazard quotient (HQ) separately for each metal; consequently, the HI was calculated. HI in soil and plants via ingestion, dermal and inhalation contact were calculated as follows:

$$HI = (D / Rfd)_{ing} + (D / Rfd)_{dermal} + (D / Rfd)_{inh} \quad (4)$$

Where Rfd were obtained for three pathways from Faiz *et al.*, (2012). A HI that < 1 put a safe limit for non-carcinogenic health impacts. Conversely, an HRI >1 indicates that non-carcinogenic effects are expected to occur (USEPA, 2001).

Cancer risk assessment

Carcinogenic risk (CR) of Cd, Co, No and Pb was calculated according to US-EPA, 2011 and Abd el-Hafez and Li, 2015 using Daily metal intake of three pathways (ingestion, dermal and inhalation) divided by carcinogenic reference dose as follows:

Table 1: Input parameters to characterize the daily metal intake of metals under study.

Parameter	Description	Value		Unit
		Adults	Children	
C	Concentration of the metal	-	-	mg/g
IR	Ingestion rate per unit time	-	-	
	Soil	100	200	mg/day
	Zea Maize*	184.4	92.2	g/day
	Wheat*	369.9	185	g/day
	Onion*	46.3	23.15	g/day
	Vegetables*	76.4	38.2	g/day
EF	Exposure frequency	-	180	day/year
ED	Exposure duration	24	6	years
BW	Body weight	70	15	kg
AT	Average time: non cancer risk	ED*365	-	Days
	cancer risk	70*365	-	Days
SL	Skin adherence factor	0.07	0.2	Mg/cm/day
SA	Exposure skin area	5700	2800	cm^2
PEF	Particle emission factor	$1.36 * 10^9$	-	m^3 /kg
ABS	Dermal absorption factor	0.01	-	Unit less
ET	Exposure time	24	-	Hours/day

Data obtained from USEPA, (1996; 2002); Van den Berg (2011) and *EAS, (2011).

Table 2: Heavy metals concentration in irrigation water of the study area

location	Sample No.	Pb	Ni	Co	Cr	Cd	B	Cu	Zn	Mn	Fe
		Concentration in mg/L									
El-Khashab canal	1	0.035	ND	0.001	ND	ND	0.006	0.015	ND	0.018	0.024
	2	0.030	ND	ND	ND	0.001	0.006	0.010	0.018	0.025	0.028
	3	0.087	ND	ND	ND	ND	0.028	0.023	0.066	0.198	0.080
	4	0.047	0.002	ND	0.001	ND	0.076	0.022	0.030	0.008	0.020
	5	0.038	0.003	ND	0.002	ND	0.049	0.023	0.016	0.009	0.020
	6	0.235	0.001	ND	ND	ND	0.031	0.014	0.027	0.012	0.014
	7	0.024	0.001	ND	0.001	0.003	ND	0.012	0.008	0.008	0.012
Iron and steel factory pipe	8	0.02	ND	ND	ND	ND	0.04	ND	1.50	0.29	0.34
	9	0.01	ND	ND	ND	ND	0.15	ND	0.06	0.01	0.01
	10	0.02	ND	ND	ND	ND	0.12	ND	0.01	0.03	0.37
El-Saff canal	11	0.050	ND	0.010	0.009	0.013	0.045	0.028	0.004	0.014	0.059
	12	0.004	ND	0.005	0.010	0.010	0.052	0.028	0.014	0.020	0.058
	13	0.010	ND	ND	0.003	ND	0.046	0.021	0.012	0.009	0.064
	14	0.007	ND	ND	ND	ND	0.046	0.014	0.027	0.008	0.035
	15	0.005	ND	0.001	ND	ND	0.083	0.006	0.015	0.028	0.078
	16	0.009	ND	ND	ND	ND	0.045	0.022	0.007	0.003	0.042
	17	0.005	ND	ND	ND	ND	0.044	0.017	0.003	0.003	0.040
El-Hager canal	18	0.089	ND	ND	ND	ND	0.132	0.037	0.475	0.289	0.102
	19	0.005	ND	ND	ND	ND	0.350	0.010	0.040	0.007	0.040
	20	0.016	ND	ND	ND	ND	ND	0.010	ND	0.002	0.030
	21	0.043	ND	ND	ND	ND	0.021	0.027	0.013	0.010	0.028
Critical limit FAO (1985)		5.0	0.2	0.05	0.1	0.01	1.0	0.2	5.0	0.2	5.0

ND: Not Detected

$$CR = D_{ing} \times SFo + D_{dermal} \times (SFo/GIABS) + D_{inh} \times IUR$$

Values of reference dose were obtained from Faiz *et al.*, (2012) and Abd el-hafez and Li (2015).

RESULTS AND DISCUSSION

Heavy metals content of water streams in the studies area

Heavy metals concentrations of water streams in the studies area are shown in Table 2. The concentration of metals in all water streams (El-Khashab, El-Saff, El-Hager canals and iron and steel discharged pipes) used for irrigation of agricultural land were within the permissible limits according to FAO (1985), with exception of El-Khashab canal (location 3), which shows high concentration value of Mn (0.198 mg/L) than the permissible limits according to FAO (1985). This was attributed to the industrial activities of iron and steel factory, which might discharge some effluents in this canal directly without any treatments. Also first two locations of El-Saff canal showed high concentration values of Cd (0.013 and 0.01 mg/L, respectively) than the permissible limits (FAO, 1985), this might be attributed to the absence of metal treatment at Helwan wastewater treatment plant, which discharge their effluents into El-Saff canal. In general, heavy metals in all water streams of the study area showed low concentration values, due to the dilution process of Nile River which considered the main source of water for these water streams.

Organic Pollutants in Water Streams of the Studies Area

Organic contaminants (total phenol and total hydrocarbon) concentrations in water streams of the study area are shown in Table 3. The results revealed that the concentration of organic contaminants measured recorded high concentration values than the permissible limits according to Egyptian Code 501 (2005). This might be attributed to the leakage of sanitation service for urban units and small scale industries units along with water streams located in the study area, which discharges their effluents into the canal directly. Also El-Saff canal that used to supply treated sewage water from Helwan wastewater treatment plant were enriched with organic pollutants because the wastewater was discharged from the plant after primary stage, which is inadequate for organic pollutants degradation.

According to Egyptian legislation (Egyptian Code 501, 2005) for irrigation water, these water streams are not suitable for irrigation; especially for vegetables and fruits. Therefore, many associated health problems are expected as a result of consuming the edible parts of plants irrigated with these water streams.

Table 3: Organic pollutants concentration in water samples of the study area

Location	Sample No.	Total phenol	T. hydrocarbon
		Concentration (mg/L)	
El-Khashab canal	1	13.7	0.68
	2	19.6	0.75
	3	6.28	1.03
	4	18.25	0.73
	5	11.58	0.74
	6	10.18	0.84
	7	5.91	0.42
Iron and steel discharge pipe	8	25.47	0.43
	9	7.54	0.46
	10	5.91	0.48
El-Saff canal	11	5.09	1.47
	12	7.62	0.84
	13	9.24	1.74
	14	5.76	1.04
	15	9.98	7.6
	16	8.8	0.88
	17	6.21	1.33
El-Hager canal	18	6.21	0.99
	19	5.47	1.01
	20	5.47	0.99
	21	8.5	0.97
Egyptian code limit 501 (2005)		0.02	0.0

Table 4: Total Trace elements content in soil of the study area

Name of stream	Sample No.	Fe	Mn	Zn	Cu	B	Cd	Cr	Co	Ni	Pb
		%	mg / kg soil								
El-Khashab canal	1	2.12	507.70	1425.70	101.80	15.60	0.30	164.00	6.30	140.00	1187.10
	3	4.08	697.70	281.90	67.70	57.80	0.50	116.40	11.80	40.30	61.30
	4	6.33	1327.65	134.80	80.25	1.50	0.00	124.45	12.55	97.70	39.15
	5	5.74	972.70	152.70	94.55	8.85	1.40	84.25	22.50	91.90	43.10
	6	6.19	5192.70	169.10	90.95	12.40	0.00	126.75	21.35	90.80	48.75
	7	7.98	845.47	203.67	100.40	6.73	0.00	134.03	16.30	97.43	40.63
Iron and steel factory Pipe	8	1.70	9727.70	6650.90	86.70	0.00	9.10	267.10	5.10	67.00	828.70
	9	4.31	1348.10	1131.90	51.60	14.10	0.00	116.40	0.00	40.30	61.30
	10	0.81	267.70	37.60	16.10	22.90	2.50	92.50	2.50	17.70	6.70
EL-Saff canal	13	1.26	153.53	51.20	14.10	7.27	0.00	101.80	0.00	8.90	5.87
	14	1.08	183.73	91.67	27.23	13.63	0.00	50.10	0.00	12.25	26.23
	15	2.61	475.07	141.83	24.60	3.50	0.00	106.07	0.00	15.50	26.17
	16	1.24	186.03	38.03	17.90	13.87	0.00	100.13	0.00	6.60	8.17
	17	3.37	493.10	72.93	35.33	48.43	0.00	63.62	0.00	41.60	12.67
El-Hager canal	21	5.13	695..8	12.30	34.40	0.00	0.00	55.80	0.00	17.00	36.60
Critical limit (European Union, 2006)			2000.0	300.0	100.0		3.0	100.0	50.0	100	100.0

Total heavy metals content in soil of the study area

Total content of heavy metals in soil of the study area are shown in Table 4. Among all water streams spread in the study area, soil irrigated with iron and steel factory discharge pipe showed high concentration values of Cd, Cr, Fe, Mn, Pb and Zn than the permissible limits according to legislation of European Union, (2002). This was attributed to the long term irrigation

Table 5: Organic pollutants concentration in soil samples of the study area

Location	Sample No.	Total phenol	T. hydrocarbon
		Concentration (mg/ kg)	
El-Khashab canal	1	14.65	115.0
	3	7.24	173.2
	4	13.8	52.2
	5	20.8	73.15
	6	16.32	69.3
	7	12.84	84.6
Iron and steel discharge pipe	8	13.76	121.1
	9	13.5	123.6
	10	12.7	116.1
El-Saff Canal	13	22.89	82.9
	14	17.15	67.8
	16	7.25	90.2
	17	6.2	83.1
	21	4.8	1.2
Egyptian Code limit 501 (2005)		0.1	0.0

Table 6: Total concentration of micro elements and heavy metals in edible plants collected from the study area

Location	Plant type	Fe	Mn	Zn	Cu	B	Cd	Cr	Co	Ni	Pb
		Plant (µg/g)									
El-Khashab canal	Garlic	1319.90	67.70	82.00	8.50	3.50	ND	24.00	ND	18.00	6.00
	Clover	355.50	18.10	49.50	10.75	6.25	ND	ND	ND	4.00	7.25
	Onion	1073.00	26.20	32.50	11.50	ND	ND	1.00	ND	ND	9.00
	Maize	2069.50	70.55	65.50	14.50	ND	ND	3.50	ND	ND	10.50
	Potatoes	562.50	21.95	44.50	0.80	0.50	ND	1.00	ND	8.50	7.00
Iron and steel factory pipe	Garlic	401.40	16.40	60.50	3.00	ND	ND	9.50	ND	7.00	ND
	Clover	1068.90	66.65	251.50	7.00	12.00	ND	21.00	ND	15.00	5.00
	Onion	914.90	73.15	369.50	4.00	ND	ND	3.50	ND	1.00	4.00
	Wheat	1463.80	159.82	146.20	9.60	3.75	0.75	37.05	ND	21.75	7.05
	Water cress	1763.90	109.70	338.00	8.00	13.50	ND	7.00	ND	5.50	4.00
EL-Saff canal	Bean	211.40	16.65	58.50	7.50	8.00	ND	1.50	ND	1.00	1.50
	Cabbage	264.40	28.05	310.50	4.00	10.50	ND	3.00	ND	2.00	3.50
	Onion	681.85	27.14	73.18	21.38	10.78	ND	8.45	ND	3.03	6.83
	Clover	1514.25	43.96	91.45	17.83	12.10	ND	9.48	ND	ND	10.33
	Garlic	297.20	8.92	59.25	9.60	2.60	ND	0.95	ND	ND	7.00
	Wheat	1801.60	47.84	68.35	11.95	0.20	ND	15.05	ND	4.15	8.70
	Maize	3238.38	50.25	43.50	16.50	8.38	ND	674.75	ND	ND	ND
	Sesame	3911.00	69.50	53.88	6.00	13.13	ND	887.50	ND	ND	0.38
	Pepper	1934.13	51.75	70.13	7.38	12.50	ND	626.50	ND	ND	1.88
El-Hager canal	Wheat	290.85	30.79	43.55	8.15	ND	ND	3.25	ND	ND	6.80
	Clover	1071.30	56.80	59.50	16.90	13.80	ND	7.20	ND	ND	8.70
	Maize	1777.6	6.4	0.1	2.4	1.3	ND	0.7	ND	ND	6.1
	Cucumber	5046.6	104.1	88	21.4	45.2	ND	10.5	ND	ND	11.4
	Mallow	4907.9	96.9	64.5	17.8	51.4	ND	3.0	ND	ND	14.8
	Gumbo	6055.9	39.4	54.4	18.2	32.2	ND	1.0	ND	ND	11.6
Critical limits (FAO/WHO, 1986)		82	3.0	27.4	3.0	20	0.21	0.0		1.63	0.43

with low quality of water (Mahmood and Malik, 2014). In addition, soil located near from industrial area of Helwan (location 3) recorded high concentration values of metals than the permissible limits set by European Union, (2002) especially B, Zn, Mn, Cr, Ni and Pb. This was attributed to the dust precipitation resulted from industrial units, which contain large amounts of these metals. Moreover, long term application of N fertilizers can increase the plant uptake and bioavailability of heavy metals (Nambiar and Ghosh, 1984). Ni also recorded high concentration values in soil irrigated with El-Khashab canal due to excessive mineral fertilization for long period, since rich clay mineral addition were interrupted from 1970 as a result of high dam construction. Kirkham (1986) was also concluded that continuous use of polluted effluents for crop production could lead to accumulation of trace elements in concentration that may be come phytotoxic. These high concentrations of metals might cause serious disadvantages for plants grown thereon. Direct toxicity to plants may be seen as inhibition of germination and growth, root damages, chlorosis (loss of chlorophyll), necroses or wilting of leaf tips and edges. Excess accumulation of trace metal may sometimes appear as a deficiency symptom for another trace element due to antagonistic effects, i.e. competition between ions during uptake. The degrees of which metals are taken up and transported within the plant differ between metals and plant species (Abdelhafez and Li, 2015). This has implications both for phytotoxic effects and metal concentrations in plant tissue used for feeding.

Organic pollutants concentration in soil samples of the studies area.

Organic contaminants concentrations in soil samples of the study area are shown in Table 5. The results revealed that the soil samples have higher concentration values of organic contaminants compared to the permissible limits according to the Egyptian Code 501 (2005). This might be attributed to the continuous loads of industrial effluents enriched with organic contaminants into water streams; which transported thereafter to the agricultural soils. Also, the unmanaged applications of pesticides, fungicides and other gross promoting compounds; which may led to excess amounts of organic hydrocarbon and pesticides to soil.

Total concentration of heavy metals in edible plants collected from the study area

Total concentration of trace metals in edible plants grown in the study area is illustrated in Table 6. The results revealed that the concentration of Mn, Zn, Cu, Cr and Pb in edible parts were higher than the permissible limits according to FAO/WHO (1986), while the other elements were within the permissible limits. Moreover, Ni recorded high concentration values compared with FAO/WHO (1986) legislation at different locations, especially plants irrigated from iron and steel factory pipe. This was attributed to the high concentration values of these elements in soil as mentioned before. Plants irrigated from iron and steel factory pipe showed the highest concentration values of micro and heavy metals, this was attributed to the high concentration values of these metals in irrigation water as a result of iron and steel factory activities. Industrial and traffic emission, burning of fossil fuel, discharge of Pb storage batteries, sewage water, and paints/ pigments may be the main sources of Pb while Cr is discharged from electroplating and pigment/pains industries, textile mills and tanneries in the city. Further, in the study area a number of industries and automobiles emit their smoke in the open air, the atmosphere of that area remains smoky and this smoke contains various toxic metals that may cause atmospheric deposition of trace metals on the leaves of vegetables, which may be a reason of higher concentration of heavy metals in leafy vegetables. Previous reports from Pakistan have indicated that the vegetables grown in wastewater accumulate higher concentration of heavy metals than those grown using ground water (Khan *et al.*, 2010; Jan *et al.*, 2010). High Cd level in plant tissues might cause gastrointestinal problems and severe toxic effects on different body parts of human like kidney, liver, testis, ovaries, nervous system and cardiovascular system(Cooke and Johnson, 1996). While existing of Pb causes hematological effects, neurological effects, renal failure, gastrointestinal effects, physiological disorders and carcinogenic effects (ATSDR, 2007). On the other hand, Cr has epidemiological effects on the urogenital system, cardiovascular problems and carcinogenic effects (Costa and Klein, 2006). All of these harmful effects put the health of people in these areas in a high risk.

Table 7: Risk quotient calculation for aquatic organisms

Name of stream	Sample No.	RQ					
		Zn	Cu	Cd	Cr	Ni	Pb
PNEC (µg/ L)		7.8	7.8	0.08	3.4	5	7.2
El-Khashab canal	1	0.00	1.92	0.00	0.00	0.00	4.86
	2	2.31	1.28	0.00	0.00	0.00	4.17
	3	8.46	2.95	0.00	0.00	0.00	12.08
	4	3.85	2.82	0.00	0.29	0.40	6.53
	5	2.05	2.95	0.00	0.59	0.60	5.28
	6	3.46	1.79	0.00	0.00	0.20	32.64
	7	1.03	1.54	0.00	0.29	0.20	3.33
Iron and steel factory pipe	8	192.31	0.00	0.00	0.00	0.00	2.78
	9	7.69	0.00	0.00	0.00	0.00	1.39
	10	1.28	0.00	0.00	0.00	0.00	2.78
El-Saff canal	11	0.51	3.59	162.50	2.65	0.00	6.94
	12	1.79	3.59	125.00	2.94	0.00	0.56
	13	1.54	2.69	0.00	0.88	0.00	1.39
	14	3.46	1.79	0.00	0.00	0.00	0.97
	15	1.92	0.77	0.00	0.00	0.00	0.69
	16	0.90	2.82	0.00	0.00	0.00	1.25
	17	0.38	2.18	0.00	0.00	0.00	0.69
El-Hager canal	18	60.90	4.74	0.00	0.00	0.00	12.36
	19	5.13	1.28	0.00	0.00	0.00	0.69
	20	0.00	1.28	0.00	0.00	0.00	2.22
	21	1.67	3.46	0.00	0.00	0.00	5.97

RQ = MEC / PNEC

Table 8: Risk quotient calculation for soil microorganisms

Name of stream	Sample No.	RQ					
		Zn	Cu	Cd	Cr	Ni	Pb
PNEC (µg/L)		26.00	89.60	1.15	62.00	50.00	166.00
El-Khashab canal	1	54.83	1.14	0.26	2.65	2.80	7.15
	3	10.84	0.76	0.43	1.88	0.81	0.37
	4	5.18	0.90	0.00	2.01	1.95	0.24
	5	5.87	1.06	1.22	1.36	1.84	0.26
	6	6.50	1.02	0.00	2.04	1.82	0.29
	7	7.83	1.12	0.00	2.16	1.95	0.24
Iron and steel factory pipe	8	255.80	0.97	7.91	4.31	1.34	4.99
	9	43.53	0.58	0.00	1.88	0.81	0.37
	10	1.45	0.18	2.17	1.49	0.35	0.04
El-Saff canal	13	1.97	0.16	0.00	1.64	0.18	0.04
	14	3.53	0.30	0.00	0.81	0.25	0.16
	15	5.46	0.27	0.00	1.71	0.31	0.16
	16	1.46	0.20	0.00	1.62	0.13	0.05
	17	2.81	0.39	0.00	1.03	0.83	0.08
El-Hager canal	21	0.47	0.38	0.00	0.90	0.34	0.22

Table 9: Non-carcinogenic hazard indexes (HI) of trace elements for adults and children in the study area

Name of stream	Plant type	Mn	Zn	Cu	B	Cd	Cr	Co	Ni	Pb
					Adults					
El-Khashab canal	Garlic	0.2012	0.0022	0.0030	0.0000	0.0010	0.4285	0.0011	0.0066	0.1339
	Onion	0.2012	0.0022	0.0030	0.0000	0.0010	0.4281	0.0011	0.0066	0.1339
	Maize	0.2014	0.0022	0.0031	0.0000	0.0010	0.4282	0.0011	0.0066	0.1347
	Potatoes	0.2032	0.0025	0.0035	0.0000	0.0010	0.4296	0.0011	0.0066	0.1377
Iron and steel pipe	Garlic	0.2014	0.0023	0.0030	0.0000	0.0010	0.4282	0.0011	0.0068	0.1349
	Onion	0.4782	0.0144	0.0017	0.0000	0.0101	0.5436	0.0002	0.0030	0.1690
	Wheat	0.4783	0.0145	0.0017	0.0000	0.0101	0.5438	0.0002	0.0030	0.1691
	Water cress	0.4787	0.0148	0.0018	0.0000	0.0101	0.5438	0.0002	0.0030	0.1694
El-Saff canal	Bean	0.4873	0.0157	0.0024	0.0000	0.0121	0.5756	0.0002	0.0058	0.1743
	Cabbage	0.4795	0.0150	0.0018	0.0000	0.0101	0.5447	0.0002	0.0031	0.1696
	Onion	0.0378	0.0005	0.0008	0.0000	0.0000	0.2889	0.0000	0.0012	0.0090
	Garlic	0.0381	0.0010	0.0009	0.0000	0.0000	0.2894	0.0000	0.0013	0.0095
	Wheat	0.0379	0.0005	0.0010	0.0000	0.0000	0.2898	0.0000	0.0012	0.0096
	Maize	0.0378	0.0005	0.0008	0.0000	0.0000	0.2891	0.0000	0.0012	0.0091
	Seasam	0.0377	0.0004	0.0008	0.0000	0.0000	0.2889	0.0000	0.0012	0.0091
	Pepper	0.0404	0.0010	0.0016	0.0000	0.0000	0.3019	0.0000	0.0017	0.0154
El-Hager canal	Wheat	0.0391	0.0006	0.0013	0.0000	0.0000	0.5811	0.0000	0.0012	0.0089
	Maize	0.0377	0.0004	0.0008	0.0000	0.0000	0.2928	0.0000	0.0012	0.0089
	Cucumber	0.0379	0.0005	0.0008	0.0000	0.0000	0.3143	0.0000	0.0012	0.0090
	Mallow	0.0897	0.0004	0.0017	0.0000	0.0000	0.1939	0.0000	0.0012	0.0258
	Gumbo	0.0881	0.0001	0.0012	0.0000	0.0000	0.1912	0.0000	0.0012	0.0208
					Children					
El-Khashab canal	Garlic	0.882	0.014	0.020	0.000	0.005	1.852	0.007	0.044	0.786
	Onion	0.882	0.014	0.020	0.000	0.005	1.851	0.007	0.044	0.786
	Maize	0.882	0.014	0.021	0.000	0.005	1.851	0.007	0.044	0.788
	Potatoes	0.886	0.014	0.021	0.000	0.005	1.854	0.007	0.044	0.795
Iron and steel pipe	Garlic	0.882	0.014	0.020	0.000	0.005	1.851	0.007	0.044	0.788
	Onion	2.096	0.090	0.012	0.000	0.055	2.350	0.001	0.020	0.993
	Wheat	2.097	0.090	0.012	0.000	0.055	2.352	0.001	0.020	0.993
	Water cress	2.097	0.091	0.012	0.000	0.055	2.351	0.001	0.020	0.993
El-Saff canal	Bean	2.117	0.093	0.013	0.000	0.059	2.425	0.001	0.026	1.005
	Cabbage	2.099	0.091	0.012	0.000	0.055	2.353	0.001	0.020	0.994
	Onion	0.165	0.003	0.005	0.000	0.000	1.249	0.000	0.008	0.053
	Garlic	0.166	0.004	0.006	0.000	0.000	1.250	0.000	0.008	0.054
	Wheat	0.166	0.003	0.006	0.000	0.000	1.251	0.000	0.008	0.054
	Maize	0.166	0.003	0.006	0.000	0.000	1.250	0.000	0.008	0.053
	Seasam	0.165	0.003	0.005	0.000	0.000	1.249	0.000	0.008	0.053
	Pepper	0.172	0.004	0.007	0.000	0.000	1.280	0.000	0.009	0.068
El-Hager canal	Wheat	0.169	0.003	0.007	0.000	0.000	1.931	0.000	0.008	0.053
	Maize	0.165	0.003	0.005	0.000	0.000	1.259	0.000	0.008	0.053
	Cucumber	0.166	0.003	0.005	0.000	0.000	1.309	0.000	0.008	0.053
	Mallow	0.390	0.001	0.009	0.000	0.000	0.833	0.000	0.008	0.133
	Gumbo	0.386	0.000	0.008	0.000	0.000	0.827	0.000	0.008	0.122

Table 10: Carcinogenic risks for Cd, Co, Ni and Pb in Helwan area for adult and children.

	Cd	Co	Ni	Pb	Total CR
CR (Adults)	7.89456E-13	1.64729E-11	4.19366E-12	0.000179164	$1.81*10^{4}$
CR (Child)	0	0	0	0.001282375	$1.28*10^{3}$

Risk assessment of heavy metals on aquatic organisms

The concentrations of heavy metals in water streams under study might be safety for irrigation according to FAO (1985), while RQ calculation revealed that there are serious problem might happen for aquatic organisms in these water streams. In ûsh, lead accumulates primarily in the gill, liver, kidney, and bone. In juvenile ûsh, lead causes a blackening of the tail followed by damage to the spine. It also reduces larvae survival. Thus, hazard impacts are expected for the aquatic organisms live in these water streams. Pb bio-concentrates in the skin, bones, kidneys, and liver of fish rather than in muscle and does not biomagnify up the food chain. This makes lead less problematic via this route of exposure. However, people who eat the whole fish and wildlife can potentially be exposed to high concentrations of lead (Wright and Welbourn, 2002).

Cu exerts a wide range of physiological effects in fishes, including increased metallothionein synthesis in hepatocytes, altered blood chemistry, and histopathology of gills and skin (Iger *et al.*, 1994). The high RQ values of Cu except in farms irrigated from iron and steel pipe predict hazard effects might take place to the aquatic organisms.

Cd also showed high RQ values in the first two sides of El-Saff canal. But this area has not any aquatic organisms due to supplementary of wastewater treatment plant effluents, which reduce dissolved oxygen to the extent that can't allow any aquatic organisms to live (Table 7).

Zn toxicosis affects fresh water fish by destruction of gill epithelium and consequent tissue hypoxia. Signs of acute Zn toxicosis in fresh water fish include osmoregulatory failure, acidosis and low oxygen tensions in arterial blood, and disrupted gas exchange at the gill surface and at internal tissue sites (Spear, 1981). Therefore, we recommend forbidding any fishing activities in these water streams, or using this kind of water for fish farms irrigation.

Risk assessment of heavy metals on soil microorganisms

Environmental risks of heavy metals to soil microorganisms were assessed for the worst-case scenario in soils located in the study area based on the risk quotients (RQ). Table 8 shows the RQ values, which was calculated using average of the concentration of metals in surface soil expressed as measured environmental concentration (MEC) and PNECs. The RQ values for Cr and Zn were assessed to pose serious risks to the soil microorganisms, since the RQ values were > 1.0 (Hernando *et al.*, 2006). Cd, Pb, Zn and Cu are expected to pose certain hazard effects on the soil microrganisms, since the RQ of these metals were above 1.0. Other elements were also expected to cause serious problems for soil microorganisms activity in some locations, especially those near from industrial units (location 3). These high RQ values of Zn and Cr might influence on the growth of soil microorganisms. The toxic mechanisms of metals in cells are not fully understood, but generally the metals tend to bind to NH- or SH-groups in proteins. Non-specific binding of metals to an organism results in toxicity due to blocking of the essential biological functional groups of biomolecules, displacing essential metal ions in biomolecules, and modifying the active conformation of biomolecules (Ochiai, 1977).

Human health risk assessment

Non-carcinogenic risk assessment

Dose is the amount of a substance available for interaction with metabolic processes after crossing the outer boundary of an organism. Metals in edible plants and soil can affect human beings through ingestion, inhalation, and dermal contact. Moreover heavy metal dose can be carcinogenic or non-carcinogenic. Calculations of dose are based on some toxicity standards. The procedures employed here and the standards used are taken from Faiz *et al.*, (2012) and US-EPA (2002) for all elements studied. Non-cancerous dose from trace elements for all three pathways is estimated from equations 1 to 3 where symbols and their meanings are given in Table 1. Accumulative dose resulting from ingestion, inhalation and dermal contact of non-carcinogen metals were calculated and used to carry out hazard quotient. Hazard quotient was employed with reference doses of these metals to calculate HIs shown in Table 9. HI puts a safe limit on non-cancerous risk of elemental dose such that HI > 1 is not recommended. High HIs values (> 2) were obtained for the elemental of Mn in locations irrigated from iron and steel pipe some vegetables (Bean, Cabbage) irrigated from El-Saff canal. Thus, a hazard health impact for populations live in Helwan district is predicted. This was attributed to the exposure of industrial units which discharge much amount of smoke that precipitated on the plants and soils besides. Moreover, the children live in Helwan also are facing damage to liver, kidney, circulatory and nerve disorders, as well as skin irritation (Kabata and Pendias, 1993), since the HIs values of the elemental of Cr are exceeding the safe limits. Additionally, farms irrigated from iron and steel discharge pipe also recorded higher values of HIs for the element of Cr than the other locations. The other studied elements were not found to cause any risks to the local population, since the HIs for studied trace elements were lower than safe level.

Cancer risk

From these data it can be seen that the level of cancer risk associated with exposure to soil of Helwan for elements studied falls below the threshold range (i.e.10^{-4} – 10^{-6}) above which environmental regulatory agencies judge the risk intolerable with the exception of lead for children, since the range of cancer risk were 1.28×10^{-3}. Total cancer risk was within the safe limits for adults, while children were highly recommended for cancer risk as shown in Table 10.

CONCLUSION

A risk assessment study was conducted to predict the expected hazardous happened to the ecosystem due to urbanization and industerlization activities at Helwan area, Egypt. Organic pollutants in water streams and soils irrigated besides recorded high concentration values than the permissible limits, while inorganic elements were within the safe limits for irrigation. Soils irrigated with the effluents of industrial units recorded high values of Mn, Zn, Cr and Pb**.** This was led to the accumulation of these elements in plant tissues grown especially edible parts. Risk assessment based on available PNEC values for the aquatic and terrestrial environment was done. Although the inorganic elements were within the safe limits of irrigation, but these low concentrations resulted in high risk quotient records for aquatic organisms. Also high levels of inorganic elements in soils besides had led to high risk quotient levels for soil microorganisms, which cause serious problems for microorganisms growth and activities in soil. The level of human exposure to that metal by tracing the route of exposure of pollutant to human body through soil and vegetables consumed was predicted. Health index (HI) was calculated using daily metals intake of metals using three pathways (Ingestion, dermal and inhalation) divided by their reference dose (Rfd). HI values of Mn predict serious hazard problems for humans consumed vegetables irrigated with iron and steel pipe. In addition, children live in Helwan facing damage to liver, kidney, circulatory and nerve disorders, as well as skin irritation, since the HIs values of the elemental of Cr are exceeding the safe limits (1). Thus, we recommend tightening on these industrial units to follow the environmental regulations related with their effluents, or moving away factories to the desert for reducing the industrial effluents in highly crowded urban areas.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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AUTHOR (S) BIOSKETCHES

Salem, T.M., Ph.D., Researcher, Environmental Department, Soils, Water and Environment Research Institute, Agricultural Research Center, Ministry of Agricultural and Land Reclamation, Giza, 12112, Egypt. Email: *tamersalem43@gmail.com*

Ahmed, Sh.S., Ph.D., Associate Professor, Environmental Department, Soils, Water and Environment Research Institute, Agricultural Research Center, Ministry of Agricultural and Land Reclamation, Giza, 12112, Egypt. Email: *shreenashraf@gmail.com*

Hamed, M.A., Ph.D., Associate Professor, Environmental Department, Soils, Water and Environment Research Institute, Agricultural Research Center, Ministry of Agricultural and Land Reclamation, Giza, 12112, Egypt. Email: *mervat94@gmail.com*

Abd ElAziz, G.H., Ph.D., Researcher, Environmental Department, Soils, Water and Environment Research Institute, Agricultural Research Center, Ministry of Agricultural and Land Reclamation, Giza, 12112, Egypt. Email: *china.hafsa@yahoo.com*

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