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HEAVY METALS LEVELS IN SHALLOW GROUNDWATER OF RURAL AREAS: RISK ESTIMATED *VIA* WATER CONSUMPTION BY FARMER'S FAMILIES

[18]

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ABSTRACT

Risk assessment of heavy metals in shallow groundwater was done on a population categories of rural areas in Etay El-Baroud district, El-Behira governorate. Mn, Zn, and Fe were the highest detected metals in all villages. It's mean values were 0.17, 0.21, and 0.39 mg. l^{-1}, respectively. The mean concentrations of examined heavy metals exceeded the permissible limits for Fe, Mn, Pb, while were under these values for Zn, Cu, Cd, and Ni. Chronic daily intake (CDI) of the examined metals was estimated through two pathways. $\sum$CDI values of ingestion pathway were higher than those resulting from dermal absorption. Nitrates were the highest absorbed contaminant in all ages especially in adults. Remarkable trends of $\sum$CDI at certain children age categories can reflect the habits and behaviour related to water contact either for drinking or other domestic purposes. Values of hazard quotient (HQ) were found to be age-specific with direct proportional relationship in both cases of exposure except at 12-18y in case of dermal absorption. NO_3 reached the highest values 34.7 ansd 48.9 at 90^{th} percentil for 12-18y and adults. In contrast, Pb was recorded the lowest values at the two pathways especially at children age categories . HI values resulting from sum of both pathways of exceeding the level of concern or threshold value (HI; 1) indicating toxic effect induced for all age categories.

1. INTRODUCTION

In developing countries, due to poor sanitation conditions and poor quality of drinking water, typical water-borne diseases and more recently diseases caused by drinking water with high concentrations of nitrates and certain metals have increased the concern over the health effects of these compounds **(Freitz, *et al* 2001)**.

Most concern over shallow groundwater contamination has centered on population associated with human activities, including municipal, agricultural, industrial and residential uses (Personal communication). Exposure to contaminants in groundwater may occur through drinking the water when using shallow groundwater as a drinking water source, through dermal contact when using to bath or domestic purposes.

EPA has set standards for more than 80 organic and inorganic contaminants that may occur in drinking water and pose a risk to human health. Chronic effects occur after a person consumes a contaminant at levels over EPA's safety standards for long period of time. The contaminant that can have chronic effects are chemicals, which have the bioaccumulation effects (e.g., pesticides, heavy metals, and disinfection by-products).

The aim of this work was to estimate the risk relating to children and adults exposure to heavy

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metals *via* domestic water originate from shallow groundwater in some villages of El-Behira governorate.

2. MATERIALS AND METHODS

2.1. Description of the studied area

Etay El-Baroud district, in El-Behira governorate with an area of 306 km^2, a total population of 369.98, and agricultural activities occupying 270.48 km^2, is characterized by presence of hand-pumps as major source of drinking and domestic purposes. The pumps are installed at average of 18-24m depth. Source of water is shallow groundwater which is potentially contaminated by agricultural drainage and sewage effluents. Seven villages were coverd during our field surveys (El-Salam, Abou-El-Fadl, El-Nokrash, El-Nebira, El-Bahy, El-Salamia and Gabares) as illustrated in **Figure (1)**. During the survey, a questionnaire regarding the lifespan, depth of hand pumps, in addition to water quality produced and its relation with the profound health problems was distributed in households randomly selected.

2.2. Water analysis

Water samples were collected on spatio-temporal basis during 2002 according to standards methods **(STM, 1998)**. Sampling were covered approximately 35 locations of hand-pumps dogged at different depths with different years of usage. Sites were selected in part based on elevated risk of metals contamination due to factors such as proximity to fertilizers applications, sewage effluents and agricultural runoff. Composite samples from deeper depths were gathered so it was preferable to take the sample when the stream flow remains quite steady and water was allowed to run for at least 15 min. Two liters of water were collected, transferred in an ice box to laboratory for analysis.

The water index was measured for PH values, electronic conductivity according to **Mc-Lean (1982)**, also slouble anions and cations. The total dissolved solids (TDS) in the form of soluble solid was measured according to STM and approximated as follow:

$$\textbf{TDS (mg. l}^{-1}\textbf{) = EC (ds. m}^{-1}\textbf{)} \times 640$$

The cations and anions were measured according to the methods of **Brunishez *et al* (1953)** and **Reitemeier (1943)**, respectively.

One liter of water was filtered on filter paper (Whateman No. 1) to prevent debris and physical impurities and acidified by nitric acid (PH= 2-2.5). 100 ml of the exctract were taken for heavy metals examination.

2.3. Flame Atomic Spectrometer (AAS)

The analysis was performed on Perkin Elemer atomic absorption spectrometry Model 2380. Measurements were made using the hallow cathod lamps for Fe, Mn, Pb Zn, Cu, Cd, and Ni. The maximum absorbnce was obtained by adjusting the lamps at specific slits and wavelenghts. The limits of detection (LOD) of the analytical method for each metal was calculated as double the standards deviation of a series of measurements of a solution, the concentration of which is distinctly detectable above, but close to blank absorbance measurments **(USEPA, 1983)**.

Standard solutions of the tested heavy metals were provided by Merck (Darmstadt, Germany), and prepared from the individual 1000 mg. l^{-1} standard in 0.1 N HNO_3. Working standards were prepared from the previous stock solutions. Deionized water was used throughout the study and the recoveries percentages ranged from 62.4 to 98.4%.

2.4. Risk Estimation

Human health risk assessment of contaminated water was estimated based on USEPA guidelines **(USEPA, 1999 and 2002)**, concentration of heavy metals and data of Integerated Risk Information System (IRIS).

Residential exposure *via* ingestion of chemicals in drinking water was estimated from the following equation:

$$CDI_{ing} = \frac{Cw.Ir.Ef.E\quad d}{Bw.At}$$

Where, C_w is the chemical concentration in water expressed as mg. l^{-1}, Ir is the ingestion rate (1.4 L. day^{-1}; adult average) **(USEPA, 1989)**, E_f is the exposure frequency expressed as day. $Year^{-1}$ and Ed is the exposure duration expressed as year. Bw is the person body weight (70 kg, average; **USEPA 1989**) and A_t is the averaging time (365 day. $Year^{-1}$).

Residential exposure in case of dermal contact with chemical in water during house activity and other was estimated as follows:

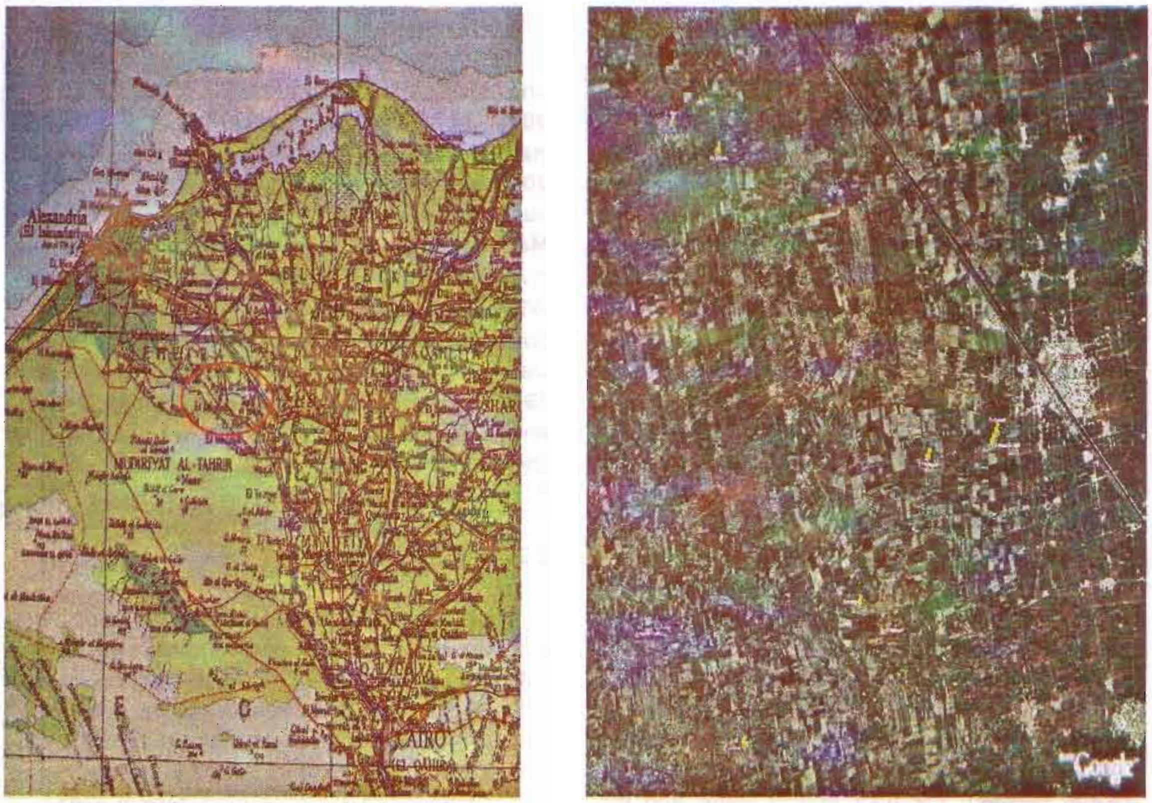

Figure 1. Illustrating map showing the sampling sites of shallow ground water

$$CDI_{dermal} = \frac{Cw.Sa.Et.Ef.Ed.Cf}{Bw.At}$$

Where, Cw is the chemical concentration in water expressed as mg. l^{-1}, Sa is the skin surface area available for contact (0.86 m^2; **USEPA 1985, 1989**), Et is the exposure time (consider local activity patterns if information is available; 2.6 hr. day^{-1}; **USEPA, 1989**), Ef is the exposure frequency (7 days. $Year^{-1}$; **USEPA, 1989**), Ed is the exposure duration expressed as year and Cf is the volumetric conversion factor for water (1 L. 1000 cm^3).

In addition, the hazard quotient (HQ) of chemicals in the two exposure routes was calculated for non-carcinogenic risk assessment. The calculation of HQ for ingestion route and dermal absorption was as follows:

$$HQ_{oral} = \frac{CDI_{oral}}{RfD}$$

Where: RfD is the reference dose for specified substance, which is listed on USEPA Website **(USEPA, 2002; IRIS, 2005)**.

Hazard Index (HI) is the sum of more than one hazard quotient for multiple substances and/ or multiple exposure pathways.

2.5. Statistical analysis

The obtained data were expressed as mean ± SE and statistically analyzed using ANOVA to determine the significant differences between treatments **(Snedecor and Cochraro, 1967)**. All data were classified and tabulated according to difference in age from 0-18y for children and 18-70y for adults. Hazard estimate calculations were performed according to the 50^{th} and 90^{th} percentiles of probability.

3. RESULTS AND DISCUSSION

The study area was anticipated to have a considerable risk of heavy metals contamination in shallow groundwater, based on abundance of agricultural land, shallow depth of water table in addition to the high permeability of the aquifers which make them highly vulnerable to contamination. Sewage effluents, agricultural runoff were the main risk factors in this study.

Through a screening questionnaire conducted in the studied villages, it was found that over 70% of residents depend mainly on shallow groundwater for drinking and domestic purposes. The lifespan of hand-pumps ranged from 5-10 years as 30% of survyed residents said, other (40%) used hand-pumps for 10-20 year and 30% use it for longer periods (>20 year). 55% of the hand-pumps were dogged at 10-20 meter depth underground, while 30% were dogged at >20 meter and 15% at less than 10 meter. In most cases, the distance that separates the hand-pumps and agricultural runoff recorded less than 5 meter which reflects lack of community awareness.

Most of the respondents (75%) were convinced that the hand-pumped drinking water in their village is contaminated and this perception originates from the opinion of 60% of them about the causal linkage between the poor quality water and the health status of the people drinking such water; other see that turbidity and unusual taste causing them getting infected with water-related diseases.

3.1. Groundwater vulnerability

The physicochemical characteristics of drinkinig water obtained by hand-pumps were measured and exihibited in **Table (1)**. The total dissolved salts (TDS) in drinking water recorded high values above mximum permissible limits (1-2 folds) **(USEPA, 2001) (Table 2)**. Samples of all investigated villages during all seasons showed that, anions and cations levels were under the permissible limits except the levels of phosphate (PO_4) and chlorids in some areas.

Mean levels of heavy metals in collected shallow groundwater are showed in **Table (3)**. Villages of El-Bahy, El-Salmia and Gabares were the most contaminated areas. Manganese (Mn), Zinc (Zn) and Ferreous (Fe) were the highest detected metals in all examined villages of Etay El-Baroud district. Their mean values were 0.17, 0.21, and 0.39 mg. l^{-1}, respectively. The order of decreased concentration was; Fe> Zn> Mn> Cu> Pb> Ni> Cd. The mean concentrations of examined heavy metals were exceeded the permissible limits for Fe, Mn and Pb, while were under these values for Zn, Cu, Cd, and Ni as shown in **Table (2)**.

In Egypt, most of the pervious studies fouced on heavy metals contamination in fish **(Rashed, 2001; Mansour and Sidky, 2002 and Abdel-Halim, 2008)**; in foods **(Salama and Radwan, 2005 and Radwan and Salama, 2006)**; and in surface water **(Mansour and Sidky, 2002 and Masoud *et al* 2004)**, but in drinking water was investigated by **El-Bahy and Ibrahim (2005)**. While, universally, most investigations were conducted on contamination of ground and drinking water **(e.g. Downs *et al* 1999; Van-Maanen *et al* 1996; Awofolu, 2006; Langah *et al* 2006; Tamasi and Cini, 2004)**. Most of the previous studies showed that, the levels of heavy metals exceeded the permissible limits of WHO.

3.2. Risk estimation

As illustrated in **Tables (5a and b)**, chronic daily intake (CDI) of the detected heavy metals was estimated through two pathways of exposure and different age categories of all residents at both 50^{th} and 90^{th} percentil of probability. Such data disclosed that $\sum$CDI values of ingestion pathway were higher than those resulting from dermal exposure pathway. CDI values at 90^{th} percentil were logically in a high trend than the 50^{th} percentil. For instance, rate of consumption of adults is higher than that for children at both probabilities. It can be noticed that CDI values for children were age-dependent where ages 6-18y recorded higher values than those at other age categories. Slight difference was observed among different age groups particularly at 90^{th} percentil of probability. Nitrates were the highest absorbed contaminants in all ages especially in adults. The order of $\sum$CDI decreased was; 0-6y> 6-9y> 9-12y> 12-18y> adults. These values were 0.22, 0.38, 0.418, 0.674 and 1.22 mg. Kg^{-1}. day^{-1}, respectively, *via* ingestion pathway.

3.3. Health hazards

Toxicity values of examined metals were showed **in Table (4)**. Non-cancer risk data were presented in **Table (6)** where, the values of HQ were found to be age-specific with direct proportional relationship in both cases of exposure except at 12-18y in case of dermal absorption. As described above, THQ values of ingestion pathway were higher than those resulting from dermal absorption. THQ values at 90^{th} percentil were logically in a high trend than the 50^{th} percentil. In case of ingestion pathway, Mn and NO_3 were the

Table 1. Average of some physicochemical characteristics of drinking water obtained by hand- pumps from Etay El-Baroud area (2002)

Village	PH	TDS	TSS	Ca^{++}	Mg^{++}	K^{+}	Na^{+} mg/l	Cl^{-}	HCO_3^{-}	NO_3^{-}	SO_4^{--}	PO_4^{--}
El-salam	7.68± 0.29	348.5± 2.88	12.2± 0.64	51.6± 1.61	17.4± 1.85	16.3± 1.80	32.0± 2.53	58.5± 4.19	294.8± 7.68	3.1± 0.79	3.7± 0.86	0. 32± 0.08
Abou El-Fadl	7.69± 0.51	343.8± 3. 39	12.6± 0.64	35.8± 1.09	20.2± 2.01	22.4± 2.12	21.8± 2.08	59.7± 3.46	282.6± 7.52	1.9± 0.62	4.8± 0.97	0. 34± 0.26
El-Nokrash	7.51± 0. 37	611.4± 3.30	17.5± 0.56	52.1± 0.96	43.7± 2.51	50. 3± 2.68	26.4± 2.10	162.7± 4.82	359.9± 7.17	0. 39± 0.24	9. 3± 1.14	0.25± 0.20
El-Bahy	7.72± 0.80	708.6± 7.68	43.4± 1.90	123. 2± 1. 32	42.6± 3.77	5.9± 1.40	136.8± 6.75	113. 3± 6.15	324. 3± 10.5	1.5± 0.71	85.9± 5. 36	1.5± 0.70
El-Salmia	7.52± 0.79	818.5± 8.25	43.7± 1.91	96.2± 2.83	32.2± 3.28	5.6± 1. 36	141.8± 5.95	173.9± 7.61	368.0± 11.1	11.2± 1.92	80. 3± 5.17	0.25± 0.05
El-Nebira	7.46± 0.42	696.7± 4.07	41.1± 0.99	84.7± 1.42	39.6± 2.57	9.5± 1.26	113.7± 4.35	118.3± 4.44	339.9± 7.53	9.8± 1.28	35.8± 2.44	0.21± 0.19
Gabares	7.52± 0.61	666.2± 5.77	50.7± 1.59	48.1± 1.55	37.9± 3.07	4.6± 1.07	142.3± 5.96	70.3± 4.19	347.3± 9.23	11.7± 1.71	42.3± 3. 26	0.09± 0.001
mean	**7.61**	**599.1**	**31.6**	**70.2**	**33.4**	**16.4**	**87.8**	**108.1**	**331.0**	**5.7**	**37.4**	**0.42**

Table 2. Standard limits of drinking water parameters (Maximum Permissible Limits) according to differrent Creteria

Parameters	WHO	EPA	EU	Egyptian
PH	6.5-8.5	6.5-8.5	6.5-8.5	6-9
Cond., µS/cm	-	-	400GV*	-
Colour	-	15 units	-	-
TDS, mg. L^{-1}	1000	500	500	1500
PO_4, „ „	0.3	-	-	0.3
SO_4, „ „	400	500	250	400
Cl^-, „ „	250	250	250	600
NO_3^-, „ „	45	45	-	45
Ca, „ „	200	-	100GV	200
Mg, „ „	150	-	50	150
Na, „ „	200	-	150	-
K, „ „	-	-	12	-
Al, „ „	-	0.05	0.2	-
B, „ „	0.3	-	1GV	-
Fe, „ „	0.3	0.3	0.2	1
Mn, „ „	0.05	0.05	0.05	0.5
Cu, „ „	1	1	0.1	1
Zn, „ „	5	5	0.1GV	5
As, „ „	0.01	0.01	0.05	0.05
Cd, „ „	0.005	0.01	0.005	0.01
Cr (total), „ „	0.05	-	0.05	0.05
Hg, „ „	0.001	-	0.001	0.001
Ni, „ „	-	0.1	0.05	0.1
Pb, „ „	0.05	0.005	0.05	0.05
Se, „ „	0.02	0.05	0.01	0.01

WHO 1993; USEPA 2001; ECS, 1994; GV*: guide val.

Table 3. Average of seasonal concentration of heavy metals (mg. L^{-1}) in drinking water obtained by hand-pumps in some villages of Etay El-Baroud district during 2002.

Village	Mn (range) mean±SE	Zn (range) mean±SE	Pb (range) mean±SE	Fe (range) mean±SE	Cu (range) mean±SE	Ni (range) mean±SE	Cd (range) mean±SE
El-salam	(0.041-0.36)	(0.01-0.11)	(0.04-0.20)	(0.008-0.44)	(0.04-0.09)	(-)	(0.001-0.004)
	0.15±0.03	**0.07±0.01**	**0.09±0.001**	**0.16±0.03**	**0.08±0.01**	**ND**	**0.003±0.001**
Abou El-Fadl	(0.036-0.38)	(0.03-0.135)	(0.02-0.06)	(0.004-0.39)	(0.10-0.11)	(-)	(ND-0.003)
	0.21±0.19	**0.08±0.02**	**0.04±0.001**	**0.11±0.02**	**0.11±0.01**	**ND**	**0.002±0.001**
El-Nokrash	(0.041-1.06)	(0.01-0.57)	(0.03-0.45)	(0.007-0.30)	(0.09-0.11)	(-)	(0.001-0.005)
	0.40±0.24	**0.17±0.03**	**0.09±0.01**	**0.08±0.01**	**0.10±0.02**	**ND**	**0.003±0.001**
El-Bahy	(0.041-0.35)	(0.001-1.01)	(0.003-0.05)	(0.02-0.95)	(ND-0.05)	(0.003-0.018)	(ND-0.003)
	0.15±0.03	**0.29±0.13**	**0.03±0.01**	**0.39±0.04**	**0.03±0.02**	**0.01±0.001**	**0.002±0.001**
El-Salmia	(0.002-0.12)	(0.095-0.82)	(0.05-0.07)	(0.008-2.11)	(0.10-0.12)	(0.003-0.008)	(-)
	0.07±0.02	**0.41±0.35**	**0.06±0.02**	**0.94±0.06**	**0.11±0.03**	**0.006±0.001**	**ND**
El-Nebira	(0.002-0.10)	(0.043-0.72)	(0.03-0.12)	(0.004-0.12)	(0.06-0.08)	(ND-0.005)	(ND-0.001)
	0.04±0.001	**0.30±0.22**	**0.09±0.02**	**0.06±0.006**	**0.08±0.02**	**0.003±0.001**	**0.0005±0.00**
Gabares	(0.07-0.10)	(0.019-0.18)	(0.03-0.06)	(0.004-2.11)	(0.05-0.10)	(0.003-0.04)	(0.001-0.002)
	0.08±0.02	**0.12±0.02**	**0.05±0.001**	**0.97±0.06**	**0.07±0.02**	**0.004±0.001**	**0.002±0.00**
mean	0.17	0.21	0.06	0.39	0.08	0.006	0.002

ND= not detected.

Table 4. Oral and dermal toxicity values of examined metals (IRIS, 2005)

Metals	Oral RfD	Dermal RfD	Weight of evidence	Safety factor	Target organ or effect
Cd	1.0E-03	1.0E-03	-	10	kidney
Cu	4.0E-02	3.9E-02	D	-	-
Pb	0.43	-	B_2	10	blood
Ni	2.0E-02	1.4E-04	-	300	Decreased organ weight
Zn	3.0E-01	2.4E-01	D	3	blood
Mn	0.005	-	-	-	-
NO_3	0.1	-	-	-	blood

highest toxic metals at all age categories. NO_3 reached the highest values 34.7 and 48.9 at 90^{th} percentil for 12-18y and adults, respectively. In contrast, Pb recorded the lowest values at the two pathways especially at children categories.

Values resulting from sum of both pathways of exceeding the level of concern or threshold value (HI; 1) indicating toxic effects induced for all age catgories. In agreement with that documented by EPA, HI that exceed 1.0, whether for a single chemical, route of exposure, and scenario, or for a combination of chemical, exposure routes and scenarios, indicate the possibility of non-cancer toxic risks from the exposure. In contrast, doses below the threshold are taken into the body, metabolized and passed out the body without harm.

Furthermore, children are at greater risk than adults from heavy metals emitted from groundwater. They are more likely to be exposed because they play outdoors and they often bring food into contaminated areas. Children are also smaller, resulting in larger doses of chemicals exposure per body weight. The developing body systems of children can sustain permanent damage if toxic exposure occur during critical growth stages **(ATSDR, 2008)**.

Recent documents reveal that nitrates cause formation of methanoglobinemia especially in young children. Also, vasodilatory effect on blood vessels. This effect induced from the conversion of nitrate to nitrite. Two to five percent of the drinking water sources on the European union countries have nitrate concentrations exceeding 50 mg. L^{-1}, which means that several million people in Europe are receiving a water supply that exceeds the limit **(Gangolli *et al* 1994)**.

Generally, metals and their salts exert toxic effects in the organisms at tissue, cellular subcellular, and molecular levels. Toxicity at the cellular levels causes deranged reproduction, differntiation and maturation resulting in teratogensis. While, at the molecular levels, some metals interact with proteins, leading to denaturation, precipitation, allosteric effects, or enzyme inhibition. An individual statments, lead poisoning as example, causes edema, a direct cytotoxic effect, and neuromuscular, gastrointestinal, renal and hematological effects. On the other hand, cadmium causes different toxic effects such as inhibition of α-antitrypsin, urinary β-micro globulin, and causes of hypertensions in cardiovascular tract **(Abou-Donia, 1992)**.

Conclusion

Based on the available information, this area is considered a public health hazard because evidence exists that exposure to contaminated water occurred. This study describes only a portion of environmental health concerns to Etay El-Baroud children in rural areas. This study also provided the most complete picture to date of environmental exposures of a subset of Minnesota children **(MDH, 2000)**. However, despite the variety of media sampled and the large number of chemicals analyzed, many potential contaminants were not measured. Due to the many assumptions necessarily incorporated into a risk assessment, hazard described may overestimate or underestimate the health impact of the exposure measured in the study.

Table 5a. Chronic daily intakes (CDI_s) of heavy metals *via* ingestion pathway to drinking water obtained by hand pumps

Metals	CDI (mg. Kg^{-1}. day^{-1})											
	Children								Adult			
	0-6		6-9		9-12		12-18		18-55		≥70	
	50th	90th	50th	90th	50th	90th	50th	90th	50th	90th	50th	90th
Mn	5.7E-03	0.039	9.8E-03	0.061	0.011	0.062	0.017	0.104	0.031	0.146	0.031	0.146
Zn	7.1E-03	0.048	0.012	0.075	0.013	0.077	0.022	0.128	0.038	0.180	0.038	0.180
Pb	2.0E-03	0.014	3.5E-03	0.021	3.8E-03	0.022	6.3E-03	0.037	0.011	0.051	0.011	0.051
Fe	0.013	0.089	0.022	0.139	0.025	0.143	0.040	0.238	0.071	0.334	0.071	0.334
Cu	2.7E-03	0.018	4.6E-03	0.029	5.0E-03	0.029	8.2E-03	0.049	0.015	0.069	0.015	0.069
Ni	2.0E-04	1.4E-03	3.5E-04	2.1E-03	3.8E-04	2.2E-03	6.2E-04	3.7E-03	1.1E-03	5.1E-03	1.1E-03	5.1E-03
Cd	6.8E-05	4.6E-04	1.2E-04	7.1E-04	1.3E-04	7.4E-04	2.1E-04	1.2E-03	3.6E-04	1.7E-03	3.6E-04	1.7E-03
NO_3	0.192	1.40	0.328	2.03	0.36	2.11	0.58	3.47	1.03	4.89	1.03	4.89
ΣCDI	**0.223**	**1.61**	**0.381**	**2.36**	**0.418**	**2.46**	**0.674**	**4.03**	**1.21**	**5.71**	**1.22**	**5.71**

Table 5b. Chronic daily intakes (CDI_s) of heavy metals *via* dermal absorption to drinking water obtained by hand pumps.

Metals	CDI (mg. Kg^{-1}. day^{-1})											
	Children								Adult			
	0-6		6-9		9-12		12-18		18-55		≥70	
	50^{th}	90^{th}	50^{th}	90^{th}	50^{th}	90^{th}	50^{th}	90^{th}	50^{th}	90^{th}	50^{th}	90^{th}
Mn	9.8E-04	3.3E-03	2.4E-03	7.9E-03	3.4E-03	0.011	2.9E-03	8.9E-03	4.3E-03	0.014	4.3E-03	0.014
Zn	1.2E-03	4.0E-03	3.0E-03	0.011	4.1E-03	0.014	3.3E-03	0.011	5.3E-03	0.018	5.3E-03	0.018
Pb	3.5E-04	1.2E-03	8.6E-04	2.8E-03	1.2E-03	3.9E-03	9.4E-04	3.2E-03	1.5E-03	5.1E-03	1.5E-03	5.1E-03
Fe	2.2E-04	1.3E-03	5.6E-03	0.018	8.1E-03	0.026	6.1E-03	0.020	9.8E-03	0.033	9.8E-03	0.033
Cu	4.6E-04	1.5E-03	1.1E-03	3.7E-03	1.6E-03	5.3E-03	1.3E-03	4.3E-03	2.0E-03	6.7E-03	2.0E-03	6.7E-03
Ni	3.5E-05	1.2E-04	8.6E-05	2.8E-04	1.2E-04	3.9E-04	9.4E-05	3.1E-04	1.5E-04	5.1E-04	1.5E-04	5.1E-04
Cd	1.2E-05	3.8E-05	2.9E-05	9.3E-05	3.9E-05	1.3E-04	3.2E-05	1.1E-04	5.1E-05	1.7E-04	5.1E-05	1.7E-04
NO_3	0.033	0.109	0.081	0.265	0.112	0.375	0.091	0.301	0.144	0.480	0.144	0.480
ΣCDI	**0.036**	**0.120**	**0.094**	**0.309**	**0.132**	**0.436**	**0.107**	**0.349**	**0.167**	**0.557**	**0.167**	**0.557**

Table 6. Non-cancer risk estimates for heavy metals in drinking water exposure in rural area

Metals	Children								Adult			
	0-6		6-9		9-12		12-18		18-55		≥70	
	50^{th}	90^{th}	50^{th}	90^{th}	50^{th}	90^{th}	50^{th}	90^{th}	50^{th}	90^{th}	50^{th}	90^{th}
	Ingestion (oral exposure):											
Mn	1.14	7.80	1.96	12.2	2.20	12.4	3.40	20.8	6.20	29.2	6.20	29.2
Zn	0.02	0.16	0.04	0.25	0.04	0.26	0.07	0.43	0.13	0.60	0.13	0.60
Pb	4.7E-03	0.03	8.1E-03	0.05	8.8E-03	0.05	0.02	0.09	0.03	0.12	0.03	0.12
Cu	0.08	0.45	0.12	0.73	0.13	0.73	0.21	1.23	0.38	1.73	0.38	1.73
Ni	0.01	0.07	0.02	0.11	0.02	0.11	0.03	0.19	0.06	0.26	0.06	0.26
Cd	0.07	0.46	0.12	0.71	0.13	0.74	0.21	1.20	0.36	1.70	0.36	1.70
NO_3	1.92	14.0	3.30	20.3	3.60	21.1	5.80	34.7	10.3	48.9	10.3	48.9
THQ	**3.24**	**30.1**	**5.57**	**34.4**	**6.14**	**35.4**	**9.74**	**58.6**	**17.5**	**82.5**	**17.5**	**82.5**
	Dermal absorption:											
Mn	0.21	0.66	0.48	1.58	0.68	2.20	0.58	1.78	0.86	2.80	0.86	2.80
Zn	5.0E-03	0.02	0.01	0.05	0.02	0.06	0.02	0.05	0.02	0.08	0.02	0.08
Pb	8.1E-04	2.8E-03	2.0E-03	6.5E-03	2.8E-03	9.2E-03	2.2E-03	7.4E-03	3.6E-03	0.01	3.6E-03	0.01
Cu	0.01	0.04	0.03	0.10	0.04	0.14	0.03	0.11	0.05	0.17	0.05	0.17
Ni	0.25	0.86	0.61	2.00	0.86	2.79	0.67	2.21	1.07	3.64	1.07	3.64
Cd	0.01	0.04	0.03	0.09	0.04	0.13	0.03	0.11	0.05	0.17	0.05	0.17
NO_3	0.33	1.09	0.81	2.65	1.12	3.75	0.91	3.01	1.44	4.80	1.44	4.80
THQ	**0.82**	2.71	**1.97**	**6.48**	**2.76**	**9.08**	**2.24**	**7.29**	**3.51**	**11.67**	**3.51**	**11.67**
HI	**4.06**	**32.81**	**7.54**	**40.88**	**8.90**	**44.48**	**11.98**	**65.89**	**21.01**	**94.17**	**21.01**	**94.17**

Furthermore, lack of toxicological data prevent interpretation of some of the measurements that were made. Finally, risk prevention should focus on reducing the volume of agrochemicals used in feilds and can leach to the groundwater and substitution with safer chemicals. Farmers should be educated about the safer use of agrochemicals, negative side effects through oral group discussions, community meetings, showing illustrative drawings and pamphlets.

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حوليـــات العلـــوم الزراعية
جامعة عين شمس ، القاهرة
مجلد(٥٤)، عدد (١)، ٢١٧-٢٣٠، ٢٠٠٩

مستوى التلوث بالعناصر الثقيلة في الماء الأرضي للمناطق الريفية: تقييم المخاطر الناجمة عن استهلاك أسر المزارعين للماء الأرضي

[١٨]

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الموجـــــز

تم تقييم مخاطر التعرض للعناصر الثقيلة خلال استهلاك الماء الأرضي لبعض المناطق الريفية بمركز ايتاى البارود- محافظة البحيرة. وقد سجلت النتائج أن المنجنيز والزنك والحديد كانوا أكثر العناصر تقديرا في كل القرى. وكان متوسط المتبقى٠,١٧, ٠,٢١, ٠,٣٩ ,مجم/لتر على التوالي. وكان متوسط هذة العناصر أعلى من الحد المسموح به بالنسبة للحديد والمنجنيز والرصاص وأقل من الحد المسموح به بالنسبة للزنك والنحاس و الكادميوم والنيكل. وقد كان المقدار الكلى الدائم المأخوذ يوميا لهذه العناصر أعلى من خلال التجريع عن الامتصاص الجلدي. النترات كانت أكثر العناصر امتصاصا بالنسبة للبالغين. معامل التأثير الغير سرطاني (HQ) وصل لأعلى قيم ٣٤,٧ ,٤٨,٩٢ للنترات عند احتمال ٩٠% من معدل الاستهلاك بالنسبة للعمر من ١٢-١٨ سنة والبالغين على التوالي. بينما سجل الرصاص أقل القيم خاصة في حالة الأطفال. وهذا يبين أن هناك مخاطر متزايدة مع تزايد معامل الخطر عن ١ في كل الأعمار في هذه المناطق.

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