HUMAN HEALTH RISK ASSESSMENT: A CASE STUDY OF HEAVY METAL CONTAMINATION OF GARDEN SOILS IN SZEGED

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Abstract
The soils of the big cities, owing to the various anthropogenic activities, can be contaminated by heavy metals. The surroundings of the roads with heavy traffic as significant metal emitter source can be contaminated by heavy metals. The hobby gardens and the vegetable gardens directly along roads can be potential risky for people since unknown amount of heavy metals can be accumulated into organization of local residents due to consumption of vegetables and fruits grown in their own garden. Most metals are well-known to have toxic characters but we have known little what extent these metals exert influence on people living directly along road with busy traffic. During our research, metal contamination has been investigated in the gardens near the roads with heavy traffic in Szeged by measuring of metal contents in soil and plants samples. Enrichment factor has been calculated with the help of control soil samples far from roads having heavily traffic. Besides determination of the metal content of soil and plant samples, soil properties basically influencing on metal mobility has been examined in order to characterize the buffering capacity of the studied soils. The health risk quotients have also been determined to evaluate human health risk of the contaminated soils.

Keywords: heavy metals, heavily traffic, garden soils, human health risk, risk quotient

1. Introduction

Urban soils are known to have peculiar characteristics such as unpredictable layering, poor structure, surface sealing, compaction, increased content of artefact and toxic elements (Craul, 1999; Alexandrovskaya and Alexandrovskiy, 2000; Norra and Stüben, 2003; Lehmann and Stahr, 2007; Puskás and Farsang, 2008). These soils are the ‘recipients’ of large amounts of heavy metals from a variety of sources including industrial wastes, vehicle emissions, coal burning waste, and other activities. There urban activities have resulted in increased heavy metal content in soil surrounding these activities (Alloway, 1990).

Heavy metals receive increasing attention due to the better understanding of their toxicological, importance in ecosystem, agriculture and human health. The accumulation of heavy metals can have different effects, either directly endangering the natural soil functions, or indirectly endangering the biosphere by bio-accumulation and inclusion in the food chain. The problem of heavy metal toxicity is exacerbated by the fact that seemingly healthy plants may accumulate them in concentrations that might endanger human health if ingested. Metals are accumulated in soil and tissues of living organisms because they are not, unlike the majority of organic compounds, subject to metabolic breakdown (Harris et al., 1996; Farsang, 2000).

The traffic is well-known for more decades to be main source of heavy metals mostly in cities. Several researches in Hungary have dealt with effects of metal contamination originating from traffic (Árkosi and Buna, 1990; Szegedi, 1990; Kádár, 1995; Kaszala and Galbács, 1999; Naszradi et al., 2003; Farsang and Puskás, 2007). According to these researches, it can be claimed which metals accumulate in soils along the roads and how far from the roads the metal accumulation can be observed. Most metals are well-known to have toxic characters but we have acquired little information about what extent these metals exert influence on people living directly along roads.

The garden soils having special functions along roads have to be emphasized among the soils of heavy traffic. In general, gardens are traditionally devoted to cultivation of vegetables and fruits. Therefore, urban gardening is both essential a source of fresh products as well as an aesthetic hobby and has a social role. The two key processes which allow human exposure to metal pollution through gardening are plant uptake where the plant is human food, and soil ingestion. Plant uptake includes both adsorption of air pollutants on plant surfaces, and uptake by the roots with translocation to edible plant tissues. Soil ingestion includes either "pica", the intentional ingestion of non-food objects, or inadvertent soil ingestion during hand-to-mouth play (Farsang and Jóri, 1999; Farsang and Rácz, 2000). Consequently, much attention has to be paid to garden soils (mostly ones near the roads of heavy traffic) since very little is known about their nature and the problems they may pose for human health.

Heavy metal content of soils are influenced by several factor including mineralogical and geochemical composition of parent rock, organic metal content, particle size distribution, soil horizontation, age, drainage, vegetation, anthropogenic and aerosol input (Kabata and Pedias, 1993). Soil properties (pH, clay content and humus content) are decisive for metal's behavior in the soil. If pH, humus and clay mineral content are high, the majority of heavy metals can be biologically inactive, since the soil can bind them in forms that are not accessible for plants (Szegedi, 2007). Consequently, besides investigation of the metals, it is essential to examine even soil properties basically influencing on metal mobility.

After considering the above facts, the major aims of the present study can be summed up as follows:

- to determine metal concentration of the soils and cultivated plants in little gardens along roads of heavy traffic in order to get to know whether the metals accumulate in these soils and plants;

- to examine soil properties basically influencing on metal mobility in order to characterize the buffering capacity of the studied soils;
- to trace spatial change of the metals with the help of enrichment factors;
- to estimate the human health risk of the contaminated soils by determination of health risk quotient (HRQ).

2. Material and methods

The selection of sampling sites has two main viewpoints: On the one hand, these sites have to be situated directly close to roads of heavy traffic in Szeged in order to detect the metals of traffic origin. On the other hand, it was important to collect soils having vegetables and fruits suitable for human consumption so putative contaminations are hazardous for human health. Consequently, soil and plant samples were taken directly near gardens along roads of busy traffic in Szeged (road number E68 to Szőreg (19759 vehicles/day); road number 47 to Hódmezővásárhely (15736 vehicles/day); road to Dorozsma (27333 vehicles/day); road number 55 to Baja (12277 vehicles/day); road number E75 to Röszke) (Pitrik, 2002) (Fig. 1). 2 average topsoil samples were also taken from 12-16 points (at a depth of 0-10 cm covering an area of 6-8 m^2) at random. Every sample along the road has a control sample situating farther from the road.

Furthermore, core samples were also collected from 2 points of soil horizon (between 40 and 50cm depth) of each sampling site (excluding the control samples) with auger. The measures were determined in the case of every soil sample; topsoil (0-10cm) and upper soil (40-50cm) were characterized with averaging of parallel average samples.

The soil samples were dried, crushed and sieved through a mesh of 2 mm for further analysis. After extraction with aqua regia (HCl/HNO_3, 3:1 solution) for total metal content and Lakanen-Erviö extraction for available metal content, the measurement were performed with an AAS type Perkin Elmer 3010 (MSZ21470-50). Different vegetables (onion, lettuce, beetroot, garlic, parsley, carrot) have also been collected in 3 ones of the gardens in order to examine the degree of metal accumulation in these plants (Table 7). 3 of the studied vegetable types were collected in spring, more ones in autumn. Parts watered, unpeeled, suitable for consumption of all the plants were investigated. After extraction of the dried, crashed plants with perchloric acid and nitric acid, the measurements were performed with also AAS type Perkin Elmer 3010.

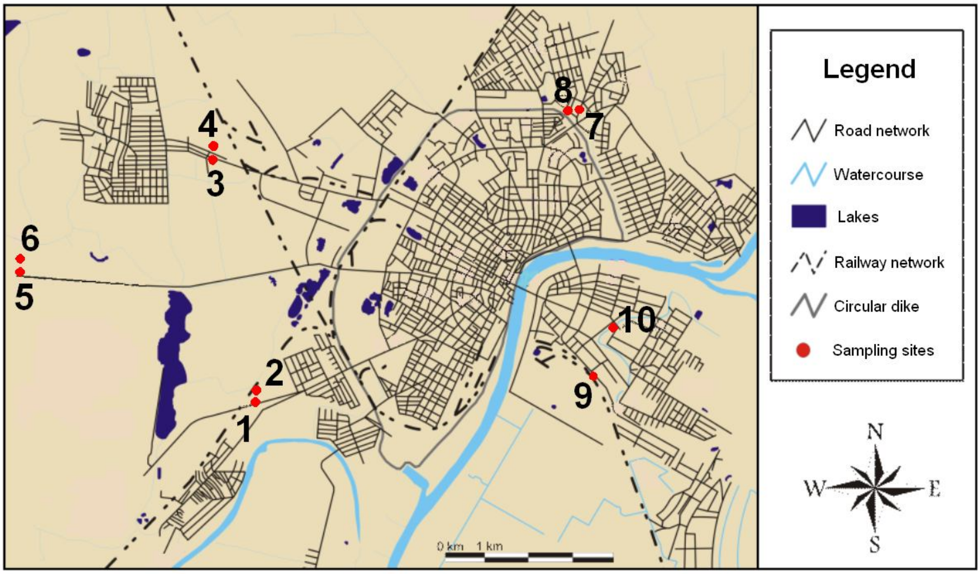

Fig. 1. Location of sample sites

Besides determination of metal concentrations, the soil properties basically influencing on metal mobility were also examined. The pH (H_2O, KCl) was recorded using a digital pH measuring device of Radelkis type. In order to capture the hidden acidity of soils the pH of a KCl soil suspension was also recorded (MSZ-080206/2-78). The organic content was measured after H_2SO_4 digestion in the presence of 0.33 M $K_2Cr_2O_7$ (MSZ-21470/52-83). The mechanical composition was determined by the yarn test of Arany, which quantifies the amount of water in cm^3 added to 100g air-dry soil sample to obtain a yarn (MSZ-080205-78).

The measured data were processed and evaluated by EXCEL 2003. The risk estimation was processed by RISC 4.0 to prepare transport modeling and risk analysis for human health in the case of contaminated area. The methods of this program are based on risk estimation guidelines of US EPA (exposure assessment, toxicity survey, risk estimation). RISC 4.0 is suitable for estimation of human health risk of the environmental elements (soil, water, air) and assessment of remediation limit values; evaluation of ecological effects of sediment and surface water, preparation of simple transport models as well as management and storage of environmental data and limit values.

Identification and calculation of exposure pathways is key role in prevention, monitoring and reduction of negative effects by chemicals causing impairment of human health and ecosystem. The exposure can be defined as the contact between a chemical and an organization. A target organism can be considered to be exposed if the chemical gets to limit between the environment and the organism and get into target point (cell, cell compartment) (Dura et al., 2001). The health risk quotient (HRQ) has been given during risk estimation. This value is ratio of the average daily intake (ADI) and tolerable daily intake (TDI) of the contaminant. If the HRQ is larger than 1, the health risk is unambiguously high. The risk categories based on this quotient are summarized in the table 1 (Németh, 2001).

Table 1. Qualification of the health risk quotient

ADI/TDI	Categories
<0.01	Negligible
0.01-0.1	Low
0.1-1	Moderate
1-10	High
>10	Very high

3. Results and discussion

3.1. Evaluation of basic soil parameters

The mechanical soil type of the studied soil is very diverse since the samples were collected from different soil types in Szeged. The mechanical soil type of sample No. 3, 5, 6 and No 1, 2, 4 and No 7, 8, 9 are sandy, sandy loam and loamy, respectively. The sample No. 10 is of organic origin.

The pH values of the studied soils are very similar: The pH(H_2O) values are between 7.46 and 8.04, whereas the pH(KCl) values are between 6.93 and 7.45. A tendency for acidity is clearly discernible from the differences of the pH(H_2O) and pH(KCl) values. However, this difference has not exceeded 1 in each sample case, either. Thus, it does not seem to be a greater tendency for acidity in the studied soils.

The values of the humus content are between 1.8 and 7.5%. In the case of sample No. 5. humus content is 1.8%, which is not so low with regard to sandy mechanical soil type. The humus content values of sample No. 6 and No. 10 are low (2.1%) and significantly high (7.5%), respectively. The other soil samples have average humus content (3%) (Table 2).

In accordance with results of the basic soil properties significantly influencing on metal mobility (pH, humus content and mechanical composition), it can be established that most studied soils have high metal binding and environmental buffering capacity owing to basic soil properties. All this is not true in case of the sample 5 and 6 since these soils have low humus content values and sandy, sandy loam mechanical soil type.

Table 2. The pH and humus content and mechanical soil type of studied soils

Sample site	Soil	pH(H_2O)	pH(KCl)	Yarn test	Humus	pH(H_2O)-
1 topsoil	Phaeozem	7.97	7.43	33.5	2.4	0.54
1upper soil		8.02	7.45	33.0	2.3	0.57
2 topsoil (control)		7.80	7.35	32.8	2.5	0.45
3 topsoil	Phaeozem	7.58	7.20	30.2	2.8	0.38
3 upper soil		7.78	7.19	27.3	2.9	0.59
4 topsoil (control)		8.04	7.27	34.7	3.9	0.77
5 topsoil	Arenosol	7.47	7.08	28.5	1.8	0.39
6 topsoil (control)		7.90	7.36	27.1	2.1	0.54
7 topsoil	Phaeozem	7.72	7.03	36.9	2.8	0.69
7 upper soil		7.69	6.95	38.4	2.7	0.74
8 topsoil (control)		7.94	7.44	40.6	3.3	0.50
9 topsoil	Fluvisol	7.73	7.09	41.5	3.5	0.64
9 upper soil		7.84	7.10	36.6	3.4	0.74
10 topsoil		7.46	6.93	42.8	7.5	0.53

3.2. The total metal content of the studied soils and enrichment factors

The metal concentrations in the soil samples were compared with the B limit value of the valid legal decree[1] (Table 3).

Table 3. A comparison of the total metal concentrations in the topsoils with the B limit value (ppm)

Sampling site	Cu	Ni	Co	Cr	Zn	Pb	Cd
1 topsoil	24.33	21.74	7.80	26.79	58.36	25.71	0.86
2 topsoil (control)	19.23	21.13	7.49	25.99	57.09	22.70	0.88
3 topsoil	**86.52**	10.94	5.15	19.54	91.34	30.61	0.95
4 topsoil (control)	27.89	21.47	6.82	27.87	91.74	35.27	**1.16**
5 topsoil	11.99	8.51	2.83	11.43	36.40	12.79	**1.01**
6 topsoil (control)	10.50	11.09	3.92	14.62	33.08	12.58	0.99
7 topsoil	49.73	19.31	7.41	30.51	98.01	34.14	**1.00**
8 topsoil (control)	25.89	19.06	7.47	28.85	73.77	38.52	0.96
9 topsoil	71.38	38.73	12.48	55.68	165.95	54.29	0.96
10 topsoil (control)	31.08	26.96	10.04	39.01	104.82	27.09	**1.06**
B value	75	40	30	75	200	100	1

The Cu exceeded the B value in the case of sample No. 3, whereas Cd approached the limit value in the case of sample No. 4, 5, 7, 10. The Ni approached the limit values in the case of no other sample but No. 9, while the Pb far fell behind the B value in case of all samples. The Co values are low in all samples, whereas high Cr

[1] 10/2000. (VI. 2) KöM-EüM-FVM-KHVM collective decrete on the threshold limit values for subsurface waters and their geological reservoirs

and Zn values can be observed in the case of sample No. 9. It is unambiguous that the highest metals values are in sample No. 9, the lowest ones in sample No. 5 (Table 3).

Enrichment factor was applied (EF=metal content of topsoil sample along road/ metal content of control topsoil sample far the road) in order to decide whether topsoils in garden along roads with heavy traffic are more contaminated than topsoils farther from roads (Table 4). The received factor values are larger than 1, then the soils along road having heavy traffic is more contaminated than ones farther from roads. If this factor around 1 or slightly below 1, then enrichment can be not detected. The EF(Cu) was above 1 in all the studied soils; in the case of sample No. 3 the EF(Cu) was triple, whereas in the case of No. 9 it was as twice much as those of control samples. However, the EF(Cu) was as nearly twice much in the case of sample No. 7, too. The EF(Zn) exceeded the 1 in four ones of five studied soils along roads. The values of EF(Ni), EF(Cr) and EF(Pb) are the highest in the case of sample No. 9. EF(Co) and EF(Cd) were slightly above 1 in the case of two samples, so there is not significant enrichment excluding EF(Co) of sample No. 9.

Table 4. EF values of soils near street of heavy traffic and the control soils

Samples	EF(Cu)	EF(Ni)	EF(Co)	EF(Cr)	EF(Zn)	EF(Pb)	EF(Cd)
1 and 2	**1.27**	**1.03**	**1.04**	**1.03**	**1.02**	**1.13**	0.98
3 and 4	**3.10**	0.51	0.76	0.70	1.00	0.87	0.82
5 and 6	**1.14**	0.77	0.72	0.78	**1.10**	**1.02**	**1.02**
7 and 8	**1.92**	**1.01**	0.99	**1.06**	**1.33**	0.89	**1.04**
9 and 10	**2.30**	**1.44**	**1.24**	**1.43**	**1.58**	**2.00**	0.91

We determined the metal concentration of the upper soil (40-50cm) in the garden soils in order to decide whether the metals originate from anthropogenic source (traffic) or not. These gardens are regularly cultivated and rotated. Furthermore, metal mobility is well-known to be depended on several soil parameters. Considering these facts, we can not draw large conclusion about origin of metals but metal concentrations in topsoil and upper soil and the enrichment factor together can help decide this question. After comparison metal concentration of topsoil with those of upper soil in the gardens, it is unambiguously that Cu accumulates in topsoil in the case of all sampling sites. This fact and the enrichment factors infer that excess Cu in soils along the roads can originate from the traffic. The origin of more metals is not so obvious. The higher concentrations preferably are in upper soil in the case of Co. Furthermore, EF(Co) is not considerably above 1 (excluding sample No. 9). Consequently, this metal is not of anthropogenic origin. The same can be represented about Cd in spite of the fact that we have measured Cd concentrations exceeding limit value. However, these higher values are both in soils along roads and in control soils. Therefore, origin of this element can not be related with traffic (Table 5). The above-mentioned correlates with other researches in Szeged (Puskás and Farsang, 2009), which prove that Pb, Zn, Ni and Cu are of anthropogenic origin, while Co, Cr and Cd are of lithogenic origin.

Table 5. The total metal content of topsoil and upper soil (40-50cm) in ppm

Sampling sites	Cu	Ni	Co	Cr	Zn	Pb	Cd
1 topsoil	24.33	21.74	7.80	26.79	58.36	25.71	0.86
1 upper soil	21.58	21.67	7.57	24.54	56.98	25.42	0.79
3 topsoil	86.52	10.94	5.15	19.54	91.34	30.61	0.95
3 upper soil	68.11	12.71	5.37	20.12	90.99	34.27	0.98
7 topsoil	49.73	19.31	7.41	30.51	98.01	34.14	1.00
7 upper soil	39.09	20.32	7.67	33.26	88.89	30.87	1.05
9 topsoil	71.38	38.73	12.48	55.68	165.95	54.29	0.96
9 upper soil	54.84	34.30	17.69	44.58	180.70	54.65	1.02

Consequently, it is obvious that mainly Cu, Zn and in less extent Ni, Cr, Pb enriched in garden soils along road depending on traffic density. The Pb concentrations are very low due to unleaded petrol usage.

3.3. Element content uptaken by plants

Besides the total metal content of soils, it is essential to determine also metal content available by plants (Szalai, 1998; Szabó et al., 2007). The evaluation of available metal content was realized with application of limit values guidelines disposable for us (Kádár, 1998).

Table 6. A comparison of the available metal concentrations in the topsoils with proposed temporary limit value (ppm)

Sampling soils	Cu	Ni	Co	Cr	Zn	Pb	Cd
1 topsoil	4.85	2.02	1.25	2.15	6.57	11.75	0.18
2 topsoil (control)	4.31	2.35	1.78	0.82	5.97	11.19	0.21
3 topsoil	**46.91**	1.79	1.14	1.30	**35.97**	17.93	0.24
4 topsoil (control)	8.54	1.99	1.11	1.59	**25.43**	19.98	0.35
5 topsoil	6.72	0.96	0.71	0.15	11.67	10.40	0.13
6 topsoil (control)	5.81	1.31	0.86	0.46	5.70	8.20	0.12
7 topsoil	22.85	3.16	1.49	0.81	**24.52**	20.89	0.25
8 topsoil (control)	14.22	2.68	1.18	1.45	12.28	15.49	0.26
9 topsoil	27.14	4.31	2.32	2.03	**53.05**	24.38	0.41
10 topsoil (control)	10.10	2.11	1.65	1.20	21.01	11.74	0.35
Proposed temporary limit value ("B value") of available metal content for soil (NH_4-acetate+ EDTA soluble)	**40**	**20**	**10**	**3**	**20**	**25**	**-**

Two elements have exceeded the limit value: on the one hand, the Cu is above permissible 40 ppm in the case of sample No. 3, just where even total metal content has exceeded the limit value. On the other hand, Zn concentrations have exceeded the limit value in the case of four sampling sites (No. 3, 4, 7, 9). In the case of each soil sample the Pb values has not exceed limit value (excluding sample No. 9 approaching the limit value), whereas Ni and Co values have not approached the limit value, either (Table 6).

The mobile metal content can be given with percentage of total metal content. It can provide information on metal binding and environmental buffering capacity of the given soil. The available Cu content is 20-56% of total Cu content (Fig. 2). The high amount of Cu concentration has mobilized at sampling sites (No. 3, 5, 6) having sandy mechanical soil type. Thus, for example in the case of sample No. 3 both total and available Cu content has exceeded the given limit value since sandy mechanical type here can not immobilized this element.

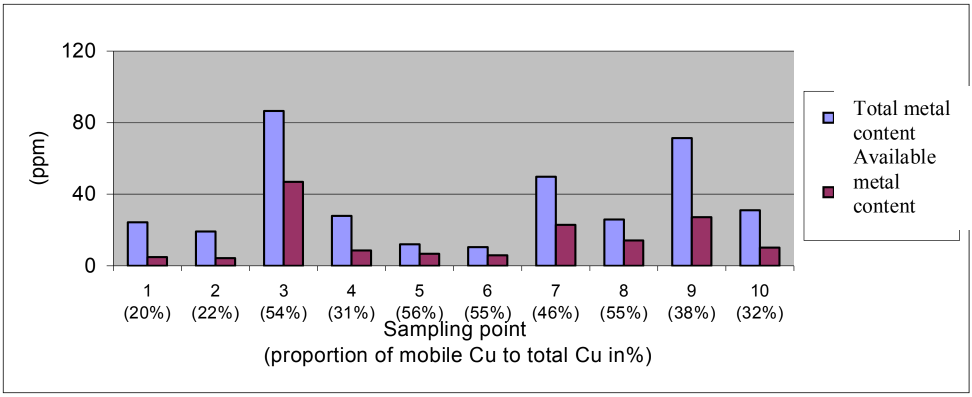

Fig. 2. A comparison of the total Cu concentrations with and Cu content available by plants in the topsoils

The available Ni content is below 16% in the case of all samples. The available Co content is also below 25% in the case of every sample excluding the No. 5 having sandy texture where this value is 25%. This value is relatively high (24%) in the sample No. 2. Both available and total Cr content are below the limit value. It is unambiguous that 81% of Pb can mobilize in the case of some samples. It refers to anthropogenic origin for the Pb since just low proportion of the geogen and pedogen metal content can mobilize during Lakanen-Erviö extraction (Farsang and Puskás, 2007).

The proportion of the mobilized Pb exceeds the 50% in the case of the sample No. 3, 4, 5, 6, 7. In the case of the sample No. 9, available Pb content approaches the temporary limit value, whereas the total Pb content is significantly below the limit value. It can be explained with high mobilization capacity of this element (Fig. 3).

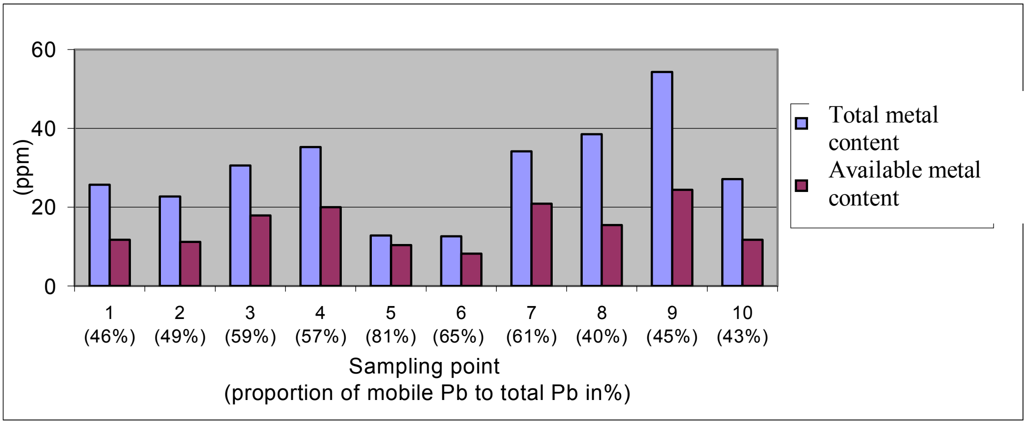

Fig. 3. A comparison of the total Pb concentrations with and Pb content available by plants in the topsoils

The total Cd content exceeded the limit value in more sample cases. Unfortunately, we can not evaluate available content of this element due to shortage of proposed limit value. With toxic character of this metal, however, it is relevant that we have to concern about 25% of available Cd content (Fig. 4).

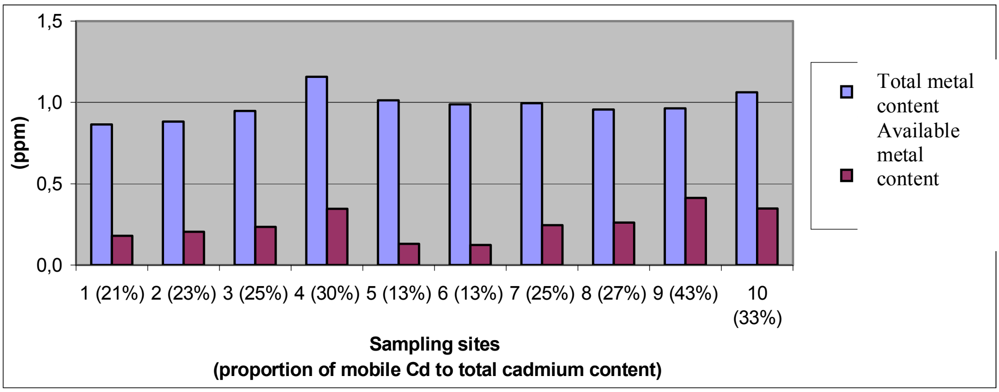

Fig. 4. A comparison of the total Cd concentrations with and Cd content available by plants in the topsoils

The total Zn content is below the limit value in the case of each sample, while available Zn content has exceeded the proposed limit value in the case of four samples (No. 3, 4, 7, 9). It is result of the high proportion of the available Zn content (>25%) of these samples. The available Zn content was the highest (39%) in the sample No. 3 (Fig. 5).

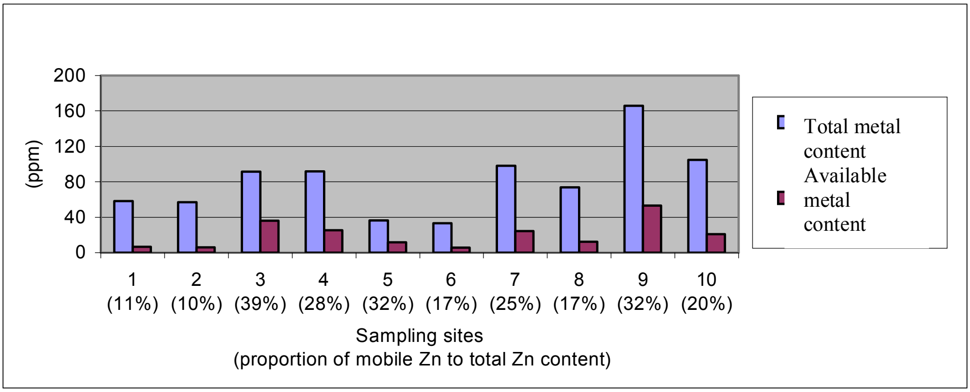

Fig. 5. A comparison of the total Zn concentrations with and Zn content available by plants in the topsoils

Consequently, it can be claimed that relatively high proportion of Cu, Pb, Cd and Zn can mobilize depending on the soil properties (pH, humus content, and mechanical composition), whereas very slightly proportion of Co, Ni and Cr can be uptaken by plant.

3.4. Metal content of the cultivated plants

The Cr either in grown-up or in young plants is below detectable limit value. This fact corresponds with very low values of available Cr content measured in soils. The parts of young plants always contain more mineral materials than those of grown-up plants since nutrient uptake takes place prior to organic matter formation (Szabó, 1998). Therefore, the Pb and Cd could be detected in only young plants (onion, lettuce, garlic). The Zn content uptaken by plants exceeded the available Zn content measured in the soil in the case of 2 samples. However, Zn content of every studied plant falls into normal category (25-150 ppm). The Ni concentration in all plants is higher than available Ni concentration in the soils on which these plants grew up. Cu content of the plants has not approached the Cu content available by plants.

The contamination of the studied plants has been evaluated in accordance with 8/1985 (X. 21.) EüM decrete (Szabó, 1998), which maximalizes the toxic element content of foodstuffs. According to this decree, the maximum value of the Pb and Cd in dried vegetable is 2 mg/kg and 0.3 mg/kg, respectively. The Cd and Pb concentrations exceeding the limit values have been detected nothing but in 3 young, undeveloped plants (garlic, onion and lettuce). Assuming the reduction of relatively concentrations of Cd, Pb in the plants during their growth and development, onion and lettuce of above-mentioned plants can endanger to human health since these plants generally are consumed in their tender condition in spring. The Pb content of the studied lettuce (5.64 ppm) is as twice and half as permissible value (2 ppm) and the Cd content of this vegetable (0.45ppm) also is higher than limit value (0.3 ppm). The Pb content of the both garlic and onion is more as twice and half much as limit value, whereas the Cd content of these plants has not exceeded the given limit value.

Table 7. Metal content of the studied plants

Sampling sites		Cu	Ni	Co	Cr	Zn	Pb	Cd
Dorozsmai street 63. (3.)	topsoil (total)	86.52	10.94	5.15	19.54	91.34	30.61	0.95
	topsoil (available)	46.91	1.79	1.14	1.30	35.97	17.93	0.24
	potato	2.81	5.27	1.69	*	9.95	*	*
	onion	11.42	*	2.00	*	25.33	4.81	0.10
Algyői street 16. (7.)	topsoil (total)	49.73	19.31	7.41	30.51	98.01	34.14	1.00
	topsoil (available)	22.85	3.16	1.49	0.81	24.52	20.89	0.25
	carrot	9.35	27.61	1.77	*	53.16	*	*
	beetroot	8.55	5.67	1.92	*	27.78	*	*
	kohlrabi	2.74	5.32	1.92	*	24.02	*	*
	lettuce	7.67	*	2.45	*	41.26	5.64	0.45
Szőregi street 45. (9.)	topsoil (total)	71.38	38.73	12.48	55.68	165.95	54.29	0.96
	topsoil (available)	27.14	4.31	2.32	2.03	53.05	24.38	0.41
	garlic	7.21	*	2.39	*	35.37	4.28	0.10
	carrot	5.51	5.87	1.77	*	25.13	*	*
	parsley	8.36	6.45	1.72	*	44.19	*	*
	white carrot	13.85	7.19	1.77	*	44.00	*	*
Average concentration of heavy metals in plants (mg/kg) (Fiedler and Rösler, 1993)		5-20	-	-	0.02-0.2	25-150	0.1-10	0.3-0.5
Permissible toxic material content of foodstuffs (dried vegetables) in mg/kg (8/1985.(X.21.) EüM decree		-	-	-	-	-	2	0.3

* under the detectable limit

In accordance with the plant researches, it can be claimed that consumption of the tender, young plant in spring (for instance spring onion and lettuce) can be riskier than that of bulbous plants in autumn.

3.6 Health risk of the contaminated soil

According to above-mentioned results, No 3, 7, 9 of the studied garden soil samples along roads are more contaminated than other two ones (No. 1, 5). This fact correlates with traffic density since three more contaminated roads have the significantly heavier traffic density than other two ones do. According to the results of three the most contaminated garden soil, during the health risk estimation process, health risk quotients of all metals were calculated as for their common effects and exposure pathways in the case of both adults and children.

The health risk quotients concerning adults are lower than 0.01 in the case of sample No 3. Consequently, degree of risk is negligible regarding ingestion and uptake through skin exposure pathways. However, the health risk quotient of Cd, Cu and Zn ranges between 0.01 and 0.1 in the case of vegetable consumption so the total risk can already be considered to be low. The degree of total risk is determined by common effect of the metals and risk by different exposure pathways. The health risk quotient is 0.11 and 0.28 in the case of adults and children, respectively. Thus, the total risk falls into moderate category in both cases.

The health risk quotient is 0.097 in the sample No. 7. Therefore, the total risk in the case of adults is slight regarding plant consumption, ingestion and uptake through skin exposure pathways. Considering the children, the total risk is moderate since the health risk quotient is 0.26. As for vegetable consumption, Cd means majority of the total risk. Thus, the health risk quotient of this metal is 0.049 and 0.11 in the case of adults and children, respectively.

The risk quotient of sample No. 9 is 0.12 and 0.34 in the case of adults and children, respectively. Consequently, the risk here is moderate considering the above-mentioned exposure pathways in both cases. According to metal concentrations of soils along three roads, the highest risk quotient values is in the case of sample No. 9, but the degree of total risk is just moderate. The vegetable consumption out of three exposure pathways has resulted in the highest risk quotient values. The same can be said about Cd out of metals (Table 8).

Table 8. The health risk quotient of metals in topsoil of sample No. 9 (calculated by RISC 4.0)

Adult Resident-Typical

	Ingestion of soil	**Dermal Contact Soil**	**Ingestion of Vegetables**	**Total**
Cadmium	1.2E-04	1.2E-06	4.7E-02	4.7E-02
Chromium (III)	1.2E-06	1.2E-07	6.1E-06	7.4E-06
Chromium (VI)	5.8E-04	5.9E-05	3.1E-03	3.7E-03
Copper	1.1E-04	1.1E-05	3.2E-02	3.2E-02
Lead	9.4E-04	9.6E-05	0.0E+00	1.0E-03
Nickel	1.2E-04	1.2E-05	3.4E-03	3.5E-03
Zinc	3.5E-05	3.5E-06	3.7E-02	3.7E-02
Total	1.9E-03	1.8E-04	1.2E-01	**1.2E-01**

Child resident -Typical				
	Ingestion of soil	**Dermal Contact Soil**	**Ingestion of Vegetables**	**Total**
Cadmium	4.1E-03	8.1E-06	1.1E-01	1.1E-01
Chromium (III)	4.0E-05	7.8E-07	1.4E-05	5.4E-05
Chromium (VI)	2.0E-02	3.9E-04	7.0E-03	2.7E-02
Copper	3.8E-03	7.5E-05	7.2E-02	7.6E-02
Lead	3.2E-02	6.3E-04	0.0E+00	3.3E-02
Nickel	4.1E-03	8.1E-05	7.7E-03	1.2E-02
Zinc	1.2E-03	2.3E-05	8.3E-02	8.4E-02
Total	6.5E-02	1.2E-03	2.8E-01	**3.4E-01**

It is unambiguous that the degree of the risk is not significant in the case of all roads, either. Thus, the risk has been estimated in the example of the most contaminated soil in such extreme case when proportion of vegetables grown on contaminated soil was increased from 0.1 to 0.8. This change means that the proportion of ones grown on contaminated garden soil of all consumed vegetables is not 10% but 80%. This extreme case could be realized if for instance the residents consumed in 80 % nothing else but vegetable yielded on their own garden. In the case of adults, soil ingestion and uptake through skin includes negligible risk, whereas the risk of vegetable consumption is moderate (0.97). In the case of children, the risk of uptake through skin, soil ingestion is negligible and low, respectively. However, the risk of vegetable consumption has already been high since totted risk quotient of the metals is 2.2 (Table 9).

In accordance with metal contents of our studied garden soils, it can be claimed that contact to soil (for. exp. during garden work, playing), soil ingestion and consumption of vegetable produced in these garden involve slight risk for the resident living here. The risk due to vegetable consumption has not exceeded the moderate category in normal case. Nevertheless, if the proportion of vegetables produced on contaminated garden soils has been increased and somebody consumes these contaminated plants, the risk will be higher. This risk can also be high in the case of children if they exclusively consume these contaminated plants.

Table 9. The health risk quotient of metals in topsoil of sample No. 9 (calculated by RISC 4.0) in that case when proportion of vegetables grown in contaminated soils is extremely increased in the consumption.

	Adult Resident-Typical			
	Ingestion of soil	**Dermal Contact Soil**	**Ingestion of Vegetables**	**Total**
Cadmium	1.2E-04	1.2E-06	3.7E-01	3.7E-01
Chromium (III)	1.2E-06	1.2E-07	4.9E-05	5.0E-05
Chromium (VI)	5.8E-04	5.9E-05	2.5E-02	2.5E-02
Copper	1.1E-04	1.1E-05	2.5E-01	2.5E-01
Lead	9.4E-04	9.6E-05	0.0E+00	1.0E-03
Nickel	1.2E-04	1.2E-05	2.7E-02	2.7E-02
Zinc	3.5E-05	3.5E-06	2.9E-01	2.9E-01
Total	1.9E-03	1.8E-04	9.7E-01	**9.7E-01**
	Child resident -Typical			
	Ingestion of soil	**Dermal Contact Soil**	**Ingestion of Vegetables**	**Total**
Cadmium	4.1E-03	8.1E-06	8.4E-01	8.5E-01
Chromium (III)	4.0E-05	7.8E-07	1.1E-04	1.5E-04
Chromium (VI)	2.0E-02	3.9E-04	5.6E-02	7.6E-02
Copper	3.8E-03	7.5E-05	5.7E-01	5.8E-01
Lead	3.2E-02	6.3E-04	0.0E+00	3.3E-02
Nickel	4.1E-03	8.1E-05	6.2E-02	6.6E-02
Zinc	1.2E-03	2.3E-05	6.6E-01	6.7E-01
Total	6.5E-02	1.2E-03	2.2E+00	**2.3E+00**

4. Conclusion

We evaluated what extent metal contamination originating from traffic exerts negative influence on people living close to road with heavy traffic. Szeged proved to be an ideal sampling area for the research since it is a line with heavy traffic. Consequently, soils and plants of gardens along 5 roads with busy traffic selected by us were investigated.

As a results of our investigation, it can be claimed that depending on the traffic density mostly Cu, Zn and to a lesser degree the Ni, Cr and Pb accumulated in garden soil along road. Ni and Cu, out of these metals approached and exceeded the limit value, respectively. However, Pb was far below the permissible value. The Cd concentration was very high and exceeded limit value in some place both in soils next to roads both in soils farther the roads. However, in accordance with enrichment factor this metal is of lithologic origin.

The toxic elements have been measured in nothing but young ones (lettuce, onion) of vegetables collected in the garden soils, whereas toxic metal content of bulbous plants has not exceeded the limit value.

Furthermore, in accordance with results of the health risk quotients, it can be claimed that contact to soil, soil ingestion and consumption of plants grown on contaminated soils have not involved risk for the resident living here. The degree of risk has considerably increased if you consume exclusively vegetables developed in contaminated soils. The risk of this significance metal excess is relatively high risk for the more sensitive children.

Consequently, it is obvious that studied metals enriched in soils along road with heavily traffic and the enrichment greatly depends on traffic density. We measured far less amount of metal in the garden soils along the roads busy traffic than in hard shoulders directly close to these roads. Three ones out of the studied five roads considered to be more contaminated depending on traffic density. Garden soils along these roads have such basic soil parameters (pH, mechanical soil type, humus content) that prove fairly high metal-binding capacity for these soils. Consequently, plants here can uptake less proportion of the metal concentrations. We have not measured toxic metal concentrations in majority of plants in the studied garden so these garden's soils have not involved significance risk for the resident here. However, it is important to note that significance consumption of lettuce, young onion and other spring vegetables have to be avoided in the case of especially children since these vegetables have contained toxic metals concentrations exceeding limit value.

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