Egypt. J. Soil Sci. **57**, No. 2, pp. 215- 232 (2017)

Accumulation of Some Heavy Metals in Plants and Soils Adjacent to Cairo – Alexandria Agricultural Highway

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AUTOMOBILE exhausts are considered the main source of air pollution with heavy metals. Airborne pollutants are precipitated on soils surrounding highways causing serious ecological hazards. The current study aimed at evaluating levels of Pb, Ni, Co and Cd in surface (015- cm) and subsurface (1540- cm) soils nearby Cairo-Alexandria agricultural highway, and their accumulation in plants grown thereon. Seven locations were sampled at interval distances 50 meters on both sides of the highway road near Toukh city (Qualubya Governorate). Cabbage and citrus plants were also sampled and separated into its parts. Results revealed that the investigated soils are contaminated with Pb, Ni and Cd. These contaminants were brought to the subsurface layers of the soil at relatively high concentrations. Total and DTPA-extractable contents of Pb and Ni in the top surface soil decreased with increasing the distance from the high way on both sides of the road. Moreover, concentrations of these metals in the cabbage parts were significantly correlated with their total and DTPA-extractable contents. However, Co and Cd in soils seemed to be not affected by the exhausts of the cars on the highway. Heavy metals decreased in cabbage parts as follows: root > stem > outer leaves > inner leaves > core. Calculated BAF values for Pb, Ni and Co were very low indicating that cabbage might be an excluder for these metals whereas, their transfer from roots to shoots (transfer factor, Ts) were high. Heavy metal concentrations in citrus decreased as leaves > flavedo > albedo > segments. Generally, concentrations of heavy metals in plants particularly Pb exceeded the permissible limits.

Keywords: Automobile exhausts, Heavy metals, Cairo-Alexandria agricultural highway, Cabbage, Citrus trees.

Pollution is the introduction of contaminants into the natural environment that causes adverse change in ecosystem (Lone *et al.*, 2008) and affect soil, plant, ground water and consequently human health (Möller *et al.*, 2005 and Abdelhafez *et al.*, 2014). Three factors determine the severity of a pollutant: its chemical nature, concentration and the persistence (Miller, 2007). Heavy metals are considered one of these pollutants which are found in soil crust naturally as trace elements by weathering of geological materials (Shea, 1996). These metal ions persist in soil and don't undergo biodegradation (Tangahu *et al.*, 2011). Heavy metal spread widely as a result of anthropogenic activities and industrial revolution. Heavy metals concentrations which exceed the permissible limits cause a serious ecological disaster (Akguc *et al.*, 2008; Huseyinova *et al.*, 2009), and cause severe health deterioration particularly to children (WHO, 1995). Heavy metals translocation via food chain and accumulation in human bodies cause potential health hazards and death.

Automobile exhausts are considered the main source of air pollution with heavy metals (Karlsson, 2004) particularly pollution with lead (Pb) in areas surrounding the highway due to adding organic lead compounds such as tetra ethyl lead and tetra methyl lead to petrol (Awofoluor, 2004). Also, Ni is found in vehicle emissions (Thomaidis *et al.*, 2003). The airborne heavy metals and other suspended pollutants are precipitated on soils surrounding highways and plants grown thereon (Hansmann and Köpple, 2000). It is worthy to mention that there is a relationship between human activities and the gradients of heavy metal

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DOI :10.21608/ejss.2016.281.1047

concentrations (MartínezGarcía *et al.*, 2001). Cadmium was found in fine soil particles (street dust) (Pagotto *et al.*, 2001 and Sezgin *et al.*, 2004) and this concentration decreased with increasing distance from the highway (Grigalavičienė *et al.*, 2005 and Nabulo *et al.*, 2006). The effect of highway traffic on contaminating the nearby lands with Co seemed to be negligible or insignificant. Soil particles contaminated with cobalt can be dispersed by wind (WHO, 2006). Such suspended particles might precipitate at high concentrations in soils near highway and, to a lower extent, at lower concentrations away from the highway. There are several forms of heavy metals in soils, a soluble form which is available to be absorbed by plants as well as complexed forms consist of heavy metals combined with organic or in organic compounds (Singh *et al.*, 2012 and Radulescu *et al.*, 2013). Heavy metals translocation from soil solution through roots to other plant parts and accumulate in high concentrations causing a serious risk on human health when these plants are consumed (Ashworth and Alloway, 2004). Some plants can absorb these soluble heavy metals and accumulate them in their organs at high levels (1 – 50 g kg^{-1} dry weight), these plants are called hyper-accumulator plants (Baker and Brooks, 1989). Cabbage is considered one of these hyper accumulators for some heavy metals which can be absorbed and accumulate in high levels in its edible parts (Radulescu *et al.*, 2013).

The main target of this study is to evaluate levels of some heavy metals in the surface (0-15 cm) and subsurface (1540- cm) soils nearby the highway of Cairo-Alexandria agricultural road because most of the previous studied were conducted on the surface layer only. Also, studying the implications of presence of such metal ions on both shallow and relatively deep rooted plants grown there on would be a matter of concern in this study. Fulfilling such targets would be helpful to evaluate how far the concentrations of the heavy metals in edible plant parts are from the permissible limits so that we may draw a suitable plan for selecting shallow and/or deep rooted plants more appropriate for cultivation in such contaminated soils.

Materials and Methods

Site description and sampling

For studying the effect of vehicle exhausts on contamination of soils with heavy metals, different locations were selected at Toukh, Qualubia governorate, Egypt nearby and away from Cairo-Alexandria agricultural highway. Seven locations were sampled from soils at 50 meters intervals starting from the immediate vicinity of the road up to a distance of 300 m from both the right and left sides of the road at two depths ,*i.e.* the top surface soil (0 – 15 cm) and sub-surface soil (15 – 40 cm). Chemical and physical characteristics of the investigated soils are presented in Table 1.

TABLE 1. Physical and chemical characteristics of soil samples

Soil Characteristics	Soil 1		Soil 2	
	Top soil 0-15 cm	Sub soil 15-40 cm	Top soil 0-15 cm	Sub soil 15-40 cm
Particle size distribution (%)				
Sand	23.2±3.4	22.2±3.2	25.8±4.2	22.0±4.1
Silt	15.3±3.4	13.6±1.9	21.2±2.4	22.9±3.2
Clay	61.5±6.9	64.2±1.8	53.0±8.6	55.1±6.4
Textural class*	Heavy clay		Heavy clay	
pH (1: 2.5 w/v)	7.2±0.3	6.9±0.6	7.7±0.6	7.1±1.2
EC** (dS m^{-1})	3.8±0.4	3.1±0.4	6.4±0.8	4.5±0.3
Calcium carbonate (g kg^{-1})	57.6±9.5	46.9±1.6	68.9±9.1	45.1±4.1
Organic matter (g kg^{-1})	27.2±3.1	21.5±0.3	39.1±2.4	21.1±0.9

Soil 1: right side of the road, Soil 2: left side of the road. *According to the international soil texture triangle.
**EC (dS m^{-1}) was determined in soil paste saturation extract

oil analysis

Heavy metals (Pb, Ni, Co, Cd) were extracted from the investigated soil samples by DTPA (Lindsay and Norvell, 1978) and corresponding soil samples were digested using a tri-acid mixture to determine total amounts of these heavy metals according to Sahrawat *et al.* (2002). Extractable Pb, Ni, Co, and Cd as well as their total contents in soil were determined by Atomic absorption spectrophotometer 210VGP.

Plant analysis

Cabbage plants (*Brassica oleracea var. capitata*) were sampled from the right side of the road, separated into leaves, stems and roots. Fruits and leaves of citrus plants (*Citrus sinensis*) were sampled from the left side of the road and fruits were separated into their parts (flavedo, albedo, and orange segment). The sampled plants were rinsed thoroughly with distilled water, separated as mentioned before, dried at 70 ºC for 72h, crushed and digested using an acid mixture of concentrated H_2SO_4 / $HClO_4$ (Grimshaw, 1987). The studied heavy metals i.e. Pb, Ni, Co and Cd were determined by Atomic absorption spectrophotometer 210VGP.

Bioaccumulation factor (BAF) was calculated in stem (BAF_{stem}), outer leaves ($BAF_{outer\ leaves}$), inner leaves ($BAF_{innerleaves}$) and core (BAF_{core}) according to Uchida *et al.* (2007) as the ratio between the concentration of heavy metal in the investigated plant part and its total content in soil. Translocation factor (Ts), the ratio between the concentration of heavy metal in the investigated areal plant part and its corresponding content in root, was calculated according to Abbas and Abdelhafez (2013). Graphs were plotted using Sigma Plot 10 program.

Results and Discussion

Heavy metals in soil

Figure 1 shows that the total and DTPA-extractable contents of Pb in the surface soil (015-cm) decreased with increasing the distance from the highway on both sides of the road. Such a result indicates that the exhausts of the cars that contain leaded petrol (UNEP, 2000) might contribute to the pollution of these soils. Average values of total Pb ranged from 135 to 253 mg kg^{-1} in the topsoil layer; whereas, the average Pb content in soils according to WHO (1995) ranges between 0.5 and 10 $mgkg^{-1}$. According to Kabata-Pendias (1995), Pb level in the investigated soils is considered exceeding the acceptable concentrations proposed by UK, Austria and Poland (100 $mgkg^{-1}$); however these concentrations are still below the Canadian (200 $mgkg^{-1}$), Japanese (400 $mgkg^{-1}$) and German acceptable levels (500 $mgkg^{-1}$). Thus, it can be deduced that also lead is exceeding the permissible limits according to some countries and within the permissible ones in some others, yet we have to consider the least concentration level of Poland for fearing of some expected implications on the plants grown on such contaminated soils and consequently the harmful effect expected to be on the plants grown thereon

Concerning total Ni content in soils, the obtained values exceeded all the above mentioned countries permissible levels (100 $mgkg^{-1}$) in soil. Contamination of soils with Ni might result from different anthropogenic sources such as vehicle emissions beside of fertilizers and organic manure (Kabata-Pendias and Pendias, 1999; Salt *et al.*, 1999; Alloway, 2013). Accordingly, we can consider that the investigated soils on both the sides of Alexandria-Cairo agricultural road are contaminated to different degrees with both Pb and Ni. Soils at the right side of the road contained relatively lower concentrations of Pb and Ni than the ones at the left side of the road. Direction of the wind might account for such variations.

On the other hand, the distribution patterns of total forms of Co and Cd in soils indicate that the soil contamination with these elements seemed not to be affected by the exhausts of the cars on the highway (Figs 3 and 4). Some other factors might contribute in contamination of these soils with Co and Cd e.g. fertilizers (Abdelhafez *et al.*, 2012). Cobalt concentrations in soils of study did not exceed the permissible level i.e. 50 $mgkg^{-1}$ according to Kabata-Pendias (1995). Although, soil cadmium exceeded the permissible levels of the UK (1 $mgkg^{-1}$), Germany (2 $mgkg^{-1}$) and Poland (3 $mgkg^{-1}$); however, these values were still below the permissible level of Canada (8 $mgkg^{-1}$). Average concentrations of total cobalt in soils of Egypt ranged between 16.5 – 26.8 $mgkg^{-1}$ (Nasseem and Abdalla, 2003). Accordingly, these soils are considered contaminated with Cd. The main sources of Cd pollution in most agricultural lands are atmospheric depositions particularly through fly ash during incineration and mineral fertilization (Alloway and Steinnes, 1999; Eckel *et al.*, 2005) as well as fossil fuel combustion (Kabata-Pendias and Mukherjee, 2007).

Migration of Pb and Ni to the subsurface layer (1540- cm) was higher in soils at the right side of the road than at the left ones (Figs 1 and 2). It is well known that Pb and Ni strongly adsorbed by soil particles and thus are considered immobile metals (Wuana & Okieimen, 2011 and Young, 2013). Generally Pb mobilization through soil horizons is very low but acidity and formation of Pb – organo complexes play a vital role in increasing Pb solubility and mobilization (Kabata-Pendias and Sadurski, 2004). Therefore, their migration to the subsurface layers is expected to be limited. Likewise, nickel mobility in soils is very slight (Zhang *et al.*, 2004). However, regular agricultural practices carried out on soils of the right side of the road before cultivating crops and vegetables ,*e.g.* incorporation of the surface with the subsurface layers through the plowing process might account partially for increasing concentrations of Pb and Ni in the subsurface layer to be slightly lower than the corresponding concentrations in the surface one. On the other hand, soils which are cultivated with citrus trees, found at the right side of the road, need somewhat limited agricultural practices which don't involve incorporation process and therefore, are still characterized by higher contents of both lead and cobalt in the surface layers than the deeper ones.

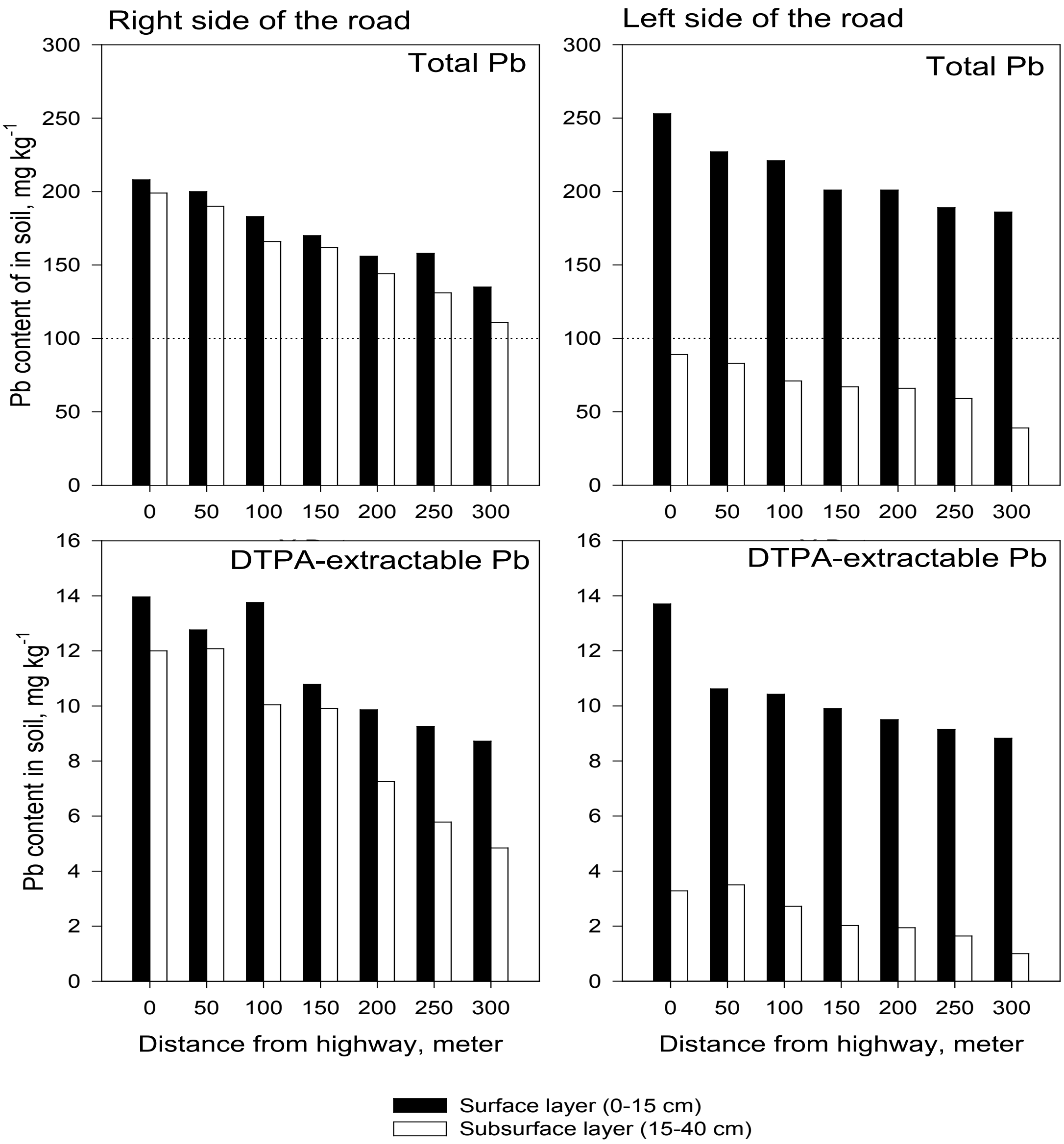

Fig 1. Total and DTPA-extractable Pb of the investigated soil (Reference maximum acceptable level (MAC) was shown by the dot-line)

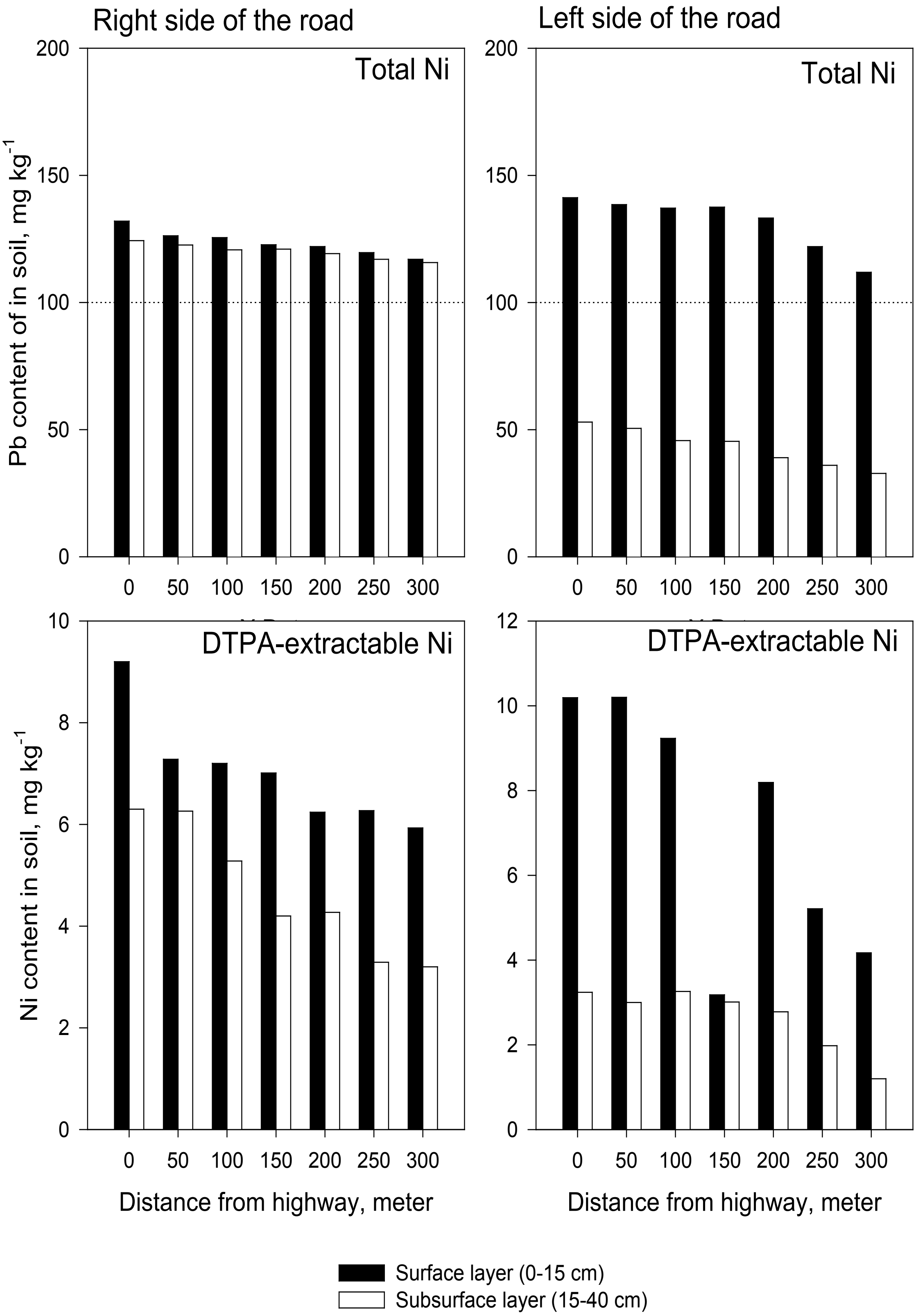

Fig. 2. Total and DTPA-extractable Ni of the investigated soil (Reference maximum acceptable level (MAC) was shown by the dot-line)

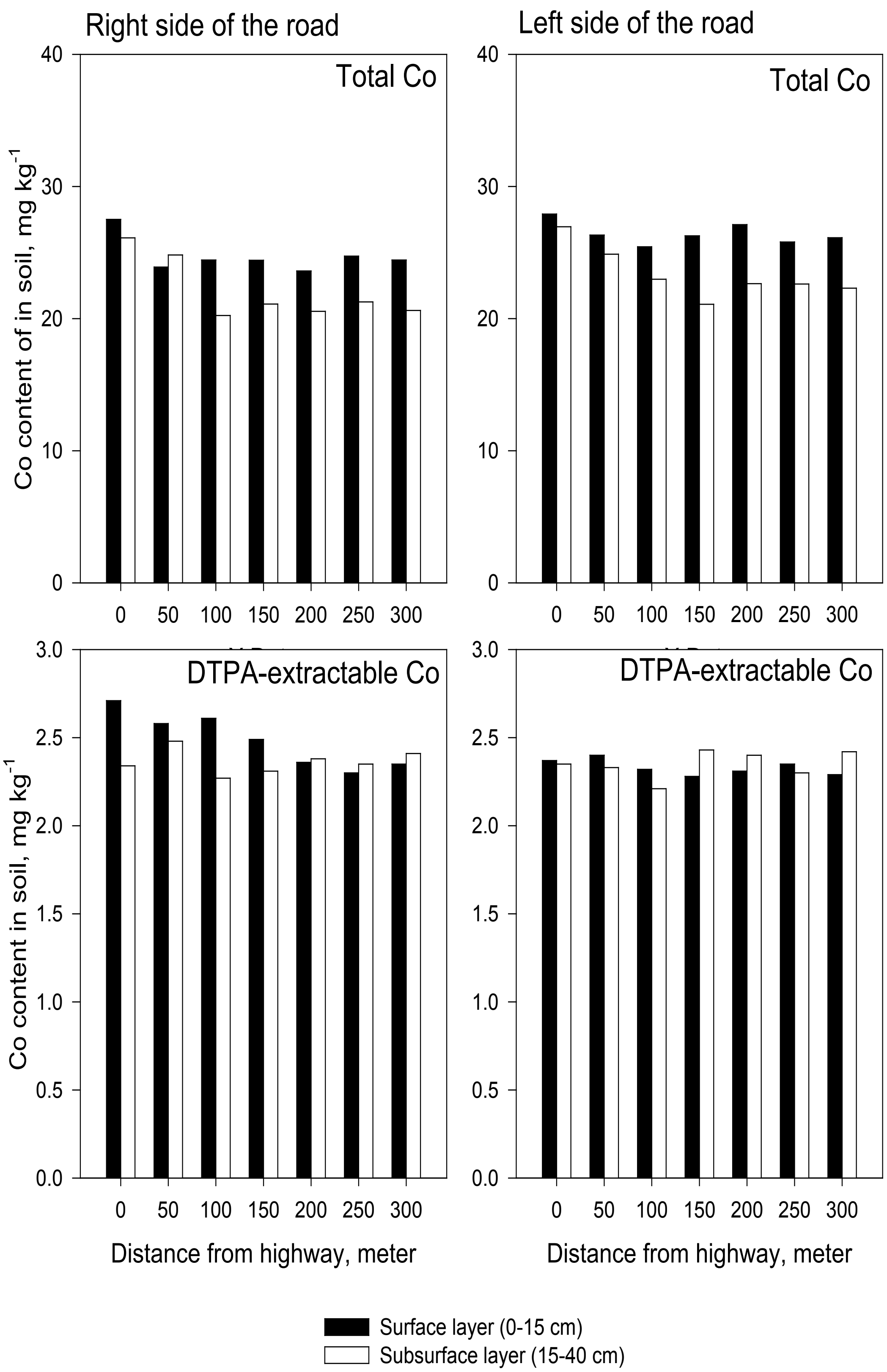

Fig. 3. Total and DTPA-extractable Co of the investigated soil.

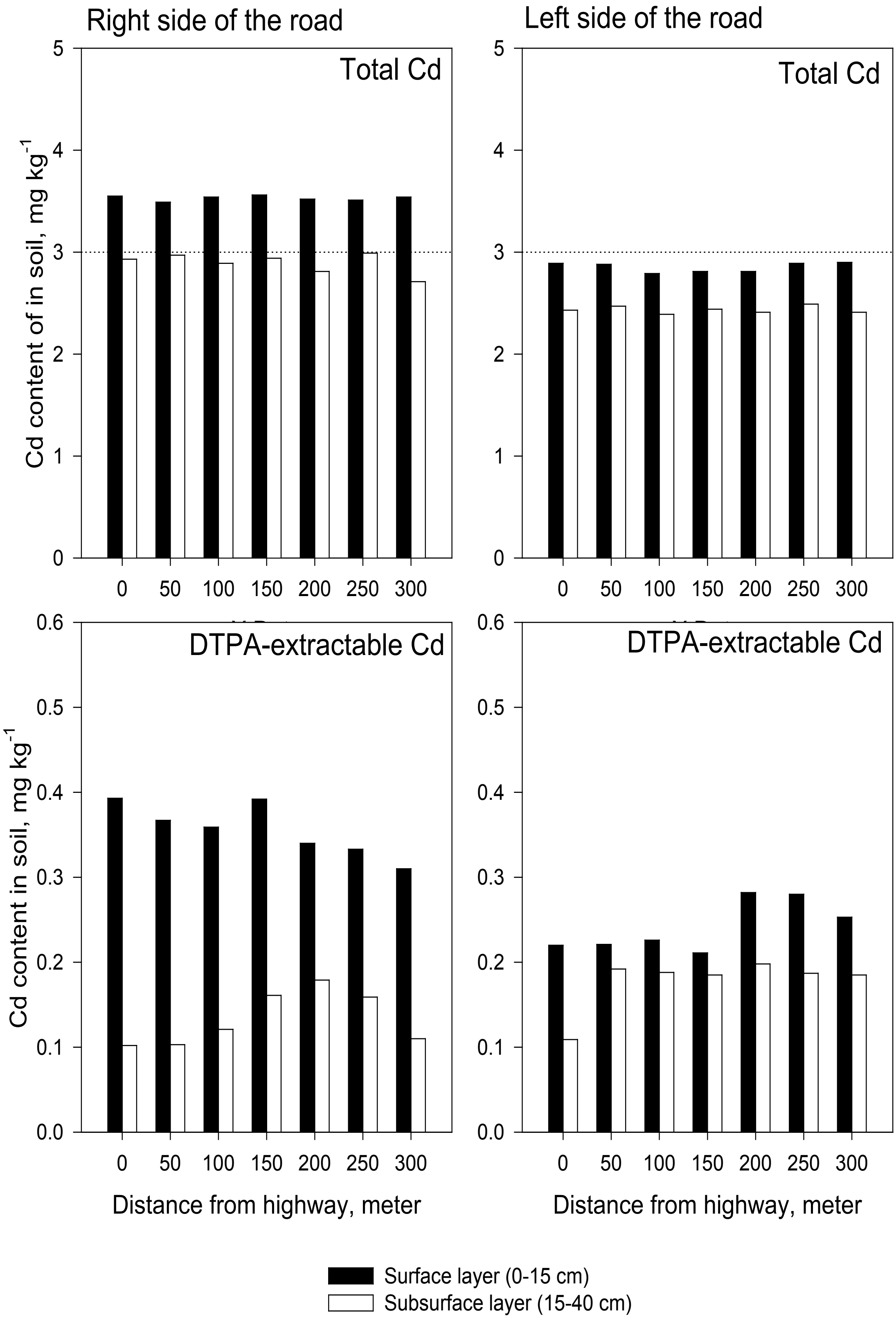

Fig. 4. Total and DTPA-extractable Cd of the investigated soil (Reference maximum acceptable level (MAC) was shown by the dot-line)

Total contents of Cd and Co in the subsurface layers of soil seemed to be almost slightly lower than their corresponding ones in the surface layer on both sides of the highway.

DTPA extractable forms of the investigated heavy metals represented only 6% of the total contents of Pb, about 7% for Ni, and around 10% of each of Co and Cd. This probably indicates that only small fractions of these heavy metals could be available to plant.

However, to what extent could these fractions accumulate in different parts of the grown plants, was the question that the current research tried to answer. It is worthy to mention that the transfer of heavy metals from soil to plant is an important criterion in food safety issues (Jolly *et al.*, 2013).

Heavy metals in cabbage plants grown on the right side of the highway

Lead in cabbage

Figure 5 reveals that concentrations of Pb within the edible parts of cabbage were much higher than the codex maximum level in leafy vegetables which is 0.1 mgkg^{-1}(IADSA, 1995) and 0.3 mgkg^{-1} for brassica (FAO and WHO, 2001). Such concentrations are at least 15 times higher than the permissible level. The threshold levels of toxicity in cabbage leaves are 150350-mgkg^{-1} (Sinha *et al.*, 2006). Thus, cabbage can accumulate high concentrations of Pb in heads without showing Pb toxicity symptoms. Moreover, cabbage could accumulate up to 5010 mg Pb kg^{-1} from soil contaminated with Pb in presence of EDTA (Shen *et al.*, 2002). Lead concentrations in the plant parts decreased, generally, in the following sequence: root > stem > outer leaves > inner leaves > core. This result confirms that inner leaves of cabbage and its core, generally, contain lower Pb concentrations and are considered more safe for ingestion than the outer leaves.

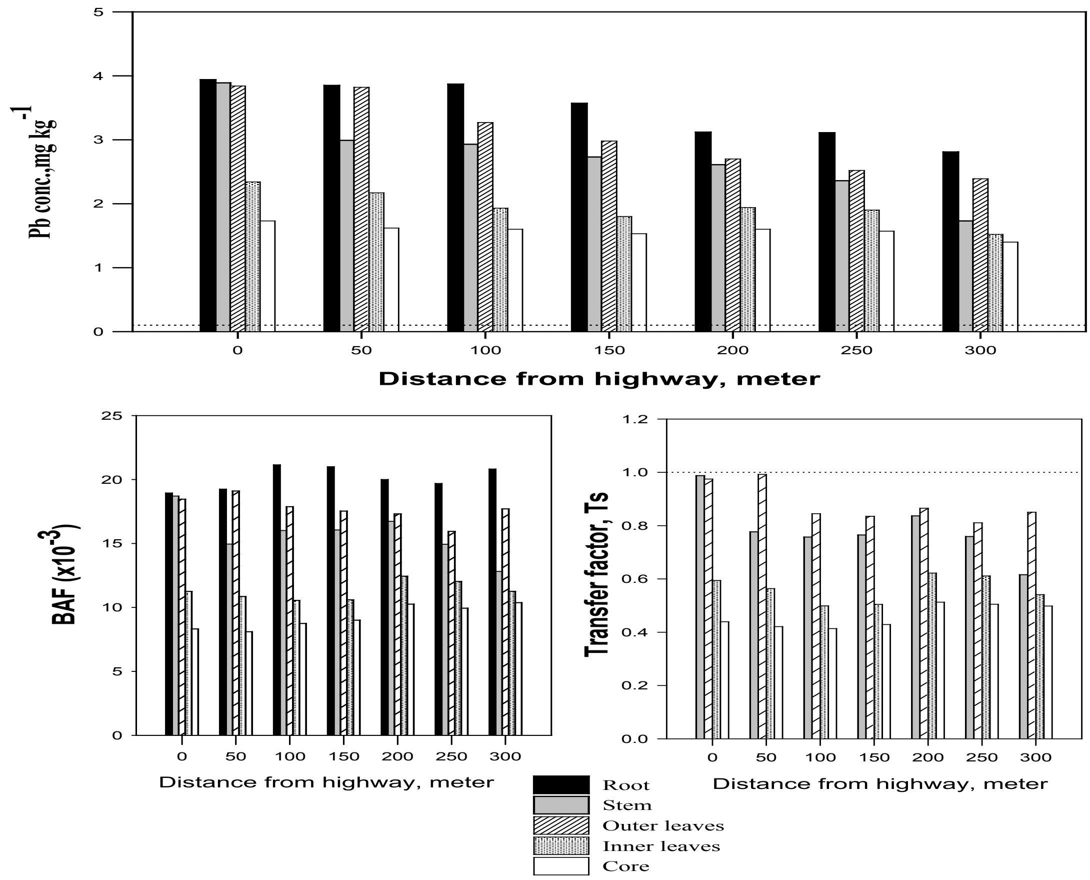

Fig. 5. Lead concentrations within the different parts of cabbage plants and the calculated biological accumulation factor (BAF) and transfer factors (Ts) as affected by the distance from the highway

Lead contents within the different plant parts significantly correlated with total and DTPA-extractable contents in soil (Table 2). Accordingly, soil contamination by lead is thought to be the main reason of Pb uptake by cabbage plants and its bio-concentration within the different plant parts. Areal uptake of Pb might be considered of less importance in this concern. The relation between Pb contents in the different plant parts and its total content in soil was calculated as biological accumulation factor (BAF) and plotted graphically in Figure 5. The calculated values were very low and this indicates that cabbage is probably not a Pb-accumulator plant, and on the other hand, it might be considered an excluder. Transfer of Pb from roots to shoots (transfer factor, Ts) was high (Ts of outer leaves ranged between 0.81 and 0.99), and relatively lower in the inner leaves (Ts of inner leaves ranged between 0.50 and 0.62) while the corresponding values of the core were the least (Ts of core ranged between 0.41 and 0.51). Sekara *et al.* (2005) found also high translocation of Pb in white cabbage from root to rosette leaves

Nickel in cabbage

Results shown in Fig 6 illustrate the distribution pattern of Ni within the different cabbage parts. Unlike Pb, Ni accumulated in relatively low concentrations in roots while sensible concentrations were translocated to the areal parts of the cabbage plants especially within the cores (high values of the translocation factor exceeding "one"). Moreover, inner leaves contained relatively higher Ni concentrations than the outer leaves. Such a result probably shows that cabbage probably needs Ni as a beneficial element (Welch & Shuman, 1995 & Yusuf *et al.*, 2011) since Ni is highly phloem-mobile (Page and Feller, 2015). Nickel concentrations exceed the permissible level (*i.e.* 0.20 mgkg^{-1}) in some of the cabbage plant parts according to the permissible levels outlined by FAO and WHO (2001).

Although, Ni concentrations within the different plant parts were significantly correlated with the total and DTPA extractable Ni in soil (Table 2); yet, very low concentrations of Ni were taken by plant roots (BAF values were very low) and this might indicate that cabbage is not a Ni-accumulator plant. Also, soil Ca might minimize Ni uptake by plant roots thus reduces its toxicity (Chaney *et al.*, 2008 and Yusuf *et al.*, 2011).

TABLE 2. Correlation coefficient values of heavy metal contents within the different cabbage parts as affected by total and available contents in soil

	DTPA-extractable	Root	stem	Outer leaves	Inner leaves	Core	DTPA-extractable	root	stem	Outer leaves	Inner leaves	core
	Lead (Pb)						Nickel (Ni)					
Total	0.922**	0.953**	0.931**	0.977***	0.913**	0.859*	0.956**	0.937**	0.913**	0.800*	0.891*	0.801*
DTPA-extractable		0.963***	0.868*	0.917**	0.765*	0.758*		0.847*	0.775*	0.681	0.789*	0.720
Root			0.874*	0.931**	0.775*	0.754*			0.938**	0.711	0.809*	0.659
Stem				0.878**	0.925**	0.937**				0.894**	0.929**	0.838*
Outer leaves					0.859*	0.773*					0.972***	0.982***
Inner leaves						0.970***						0.962**
	Cobalt (Co)						Cadmium (Cd)					
Total	0.576	0.044	0.136	0.486	0.435	0.003	0.321	0.162	0.491	-0.18	0.414	0.487
DTPA-extractable		-0.562	-0.319	0.548	0.120	-0.63		-0.559	-0.309	0.739	0.018	0.685
Root			0.173	-0.0343	0.069	0.280			0.376	-0.355	0.591	-0.018
Stem				-0.168	0.688	0.553				-0.156	0.505	0.083
Outer leaves					0.342	0.089					0.409	0.382
Inner leaves						0.335						0.227

Note: * $p< .05$; ** $p<.01$; *** $p< .001$

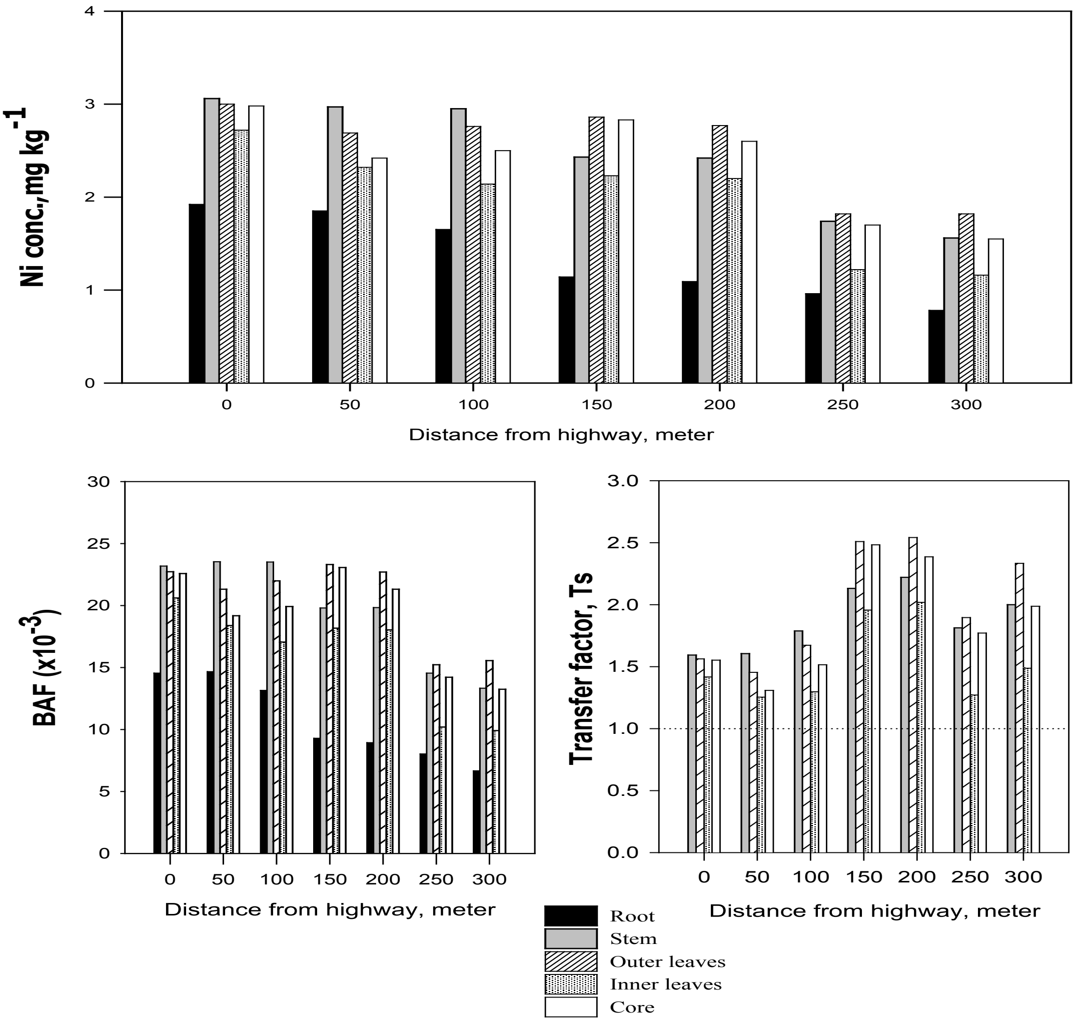

Fig. 6. Nickel concentrations within the different parts of cabbage plant (A) and the calculated biological accumulation factor (BAF) and transfer factors (Ts) as affected by the distance from the highway

Cobalt in cabbage

Cobalt concentrations within the different plant parts were relatively low compared with the corresponding concentrations of Pb and Ni (Fig. 7). Although, roots retain relatively high concentrations of Co; yet considerable concentrations of Co were translocated to the areal parts of cabbage plants. Probably, Co is a beneficial element (Marschner, 1995; Bakkaus *et al.*, 2005). The highest concentrations of Co were detected in stems and this probably indicates that Co is a mobile element within the plant. Welch and Shuman (1995) classified Co as an intermediate phloem mobile element. Normal concentrations of cobalt in plants ranges between 0.110- mgkg^{-1} (Bakkaus *et al.*, 2005). Concentration of cobalt in cabbage samples grown nearby the highway did not exceed this normal level

Within the areal parts of cabbage, Co concentrations decreased as follows: outer leaves > inner leaves > core. Low values of the BAF indicates low uptake of Co from soils by cabbage. Translocation of Co from roots to shoots was high (values of the translocation factor exceeded “one” for stem and outer leaves) and, generally, this factor decreased in the following sequence: stem > outer leaves > inner leaves > core.

Correlation analyses indicate that Co concentrations within cabbage parts were neither significantly affected by the total contents in soil nor by the DTPA-extractable form (Table 2). Collins and Kinsela (2011) recorded that soil total content of cobalt has no impact on its uptake by plants. Other soil factors might affect Co availability and uptake ,*e.g.* soil-Mn affect Co availability in soil. Likewise, no significant correlations were detected between Co concentrations and each of the different plant parts.

Cadmium in cabbage

Cabbage maintains relatively low concentrations of Cd within its outer and inner leaves and the core (Fig. 8). Higher concentrations of Cd were detected mainly in roots and stems. Xian (1989) went almost to similar results and recorded higher concentrations of Cd in roots than in shoots. On the other hand, Sêkara *et al.* (2005) found higher concentrations of Cd in leaves of white cabbage than in roots. The codex maximum level of Cd in leafy vegetables is 0.2 $mgkg^{-1}$ (IADSA, 1995; FAO and WHO, 2001) and the values of Cd in edible parts of cabbage obtained from this study were almost double or triple this codex level. This indicates high potential health risk for man feeding on cabbage obtained from the studied locations. Values of the biological accumulation factor were high enough to recommend cabbage as accumulator plants for Cd. Translocation of Cd to the areal parts was low; therefore, Cd was probably immobilized through its pathway from roots and hence, its concentration was minimized in the plant leaves and core. In this concern, it was found that *Brassica campestris* L. is a Cd-accumulating crop which can reduce effective hazard potential of Cd in soil (Su *et al.*, 2010).

Concentrations of Cd within the different cabbage parts were not significantly affected by the corresponding total or DTPA-extractable concentrations in soil (Table 2). This might take place through binding Cd on the pectic sites and hystidyl groups of root cell walls (Nishizono *et al.*, 1989 and Leita *et al.*, 1996). The concentrations of Cd within the different plant parts did not correlate with each other. Mostly, Cd toxicity stimulated the synthesis of phytochelations and vacuole compartmentalization to detoxify Cd (Sanità di Toppi and Gabbrielli, 1999). Thus, Cd was immobilized and distributed within the different plant parts through its pathway from roots to the core. Immobilization and partitioning capacity may vary among the different plant parts.

Heavy metals in citrus trees grown on the left side of the highway

In spite of the long pathway of the investigated heavy metals from soil to citrus leaves, concentrations of these metals in leaves were relatively high (Fig. 9). These concentrations were comparable to the concentrations of Ni (215- mg kg^{-1}) and Co (0.10.2- mg kg^{-1}) found by Romero *et al*. (2012) in citrus leaf samples collected from cultivated lands near mines, and lower than the concentrations of Pb 0.82.6- $mgkg^{-1}$) and Cd (<0.01 $mgkg^{-1}$) in our leaf samples. In spite of that, concentrations of Pb and Ni were still below toxic levels in citrus leaves mentioned by Aucejo *et al.* (1997) which were 1020- $mgkg^{-1}$ for Pb and 50100- $mgkg^{-1}$ for Ni.

According to FAO and WHO (2001), Pb and Cd exceeded the permissible limits in fruits i.e. 0.20 and 0.05 mg kg^{-1}, respectively.

Pronounced reductions in concentrations of these metals occurred according to the following sequence: flavedo > albedo > segments. This sequence indicates that citrus plants probably minimized the translocation of heavy metals to the edible parts of the plant to reach less than 8, 16, 19 and 8% of the corresponding concentrations in leaves for Pb, Ni, Co and Cd, respectively. It is worthy to mention that flavedo and albedo are rich in pectin (Mamma and Christakopoulos, 2014) which can bind heavy metal ions (Kartel *et al.*, 1999). Heavy metals are sorbed on their active functional groups (Marín *et al.*, 2010). Thus, concentration of these metals in citrus segments seemed to be relatively low.

Caselles (1998) conducted his study on a citrus farm next to a busy motor road in Spain and found also that Pb concentrations decreased in leaves of citrus with increasing the distance from the motor road; however, the concentrations obtained in this study (around 15 mg Pb kg^{-1}) were much higher than the corresponding concentrations obtained therein

Significant correlations were recorded for Pb and Ni concentrations among different plant tissues ,*i.e.* leaves, flavedo, albedo and segments (Table 3). However, no significant correlation was detected among these parts for Co or Cd. Total and DTPA-extractable contents of Pb and Ni in soil had the largest impact on their bio-concentrations in different citrus parts. However, soil Co and Ni did not affect significantly their concentrations within the investigated parts of the plant.

TABLE 3. Correlation coefficient values of heavy metals in citrus as affected by their total and DTPA-extractable contents in soil

	DTPA-extractable	Leaf	Flavedo	Albedo	Segment	DTPA-extractable	Leaf	Flavedo	Albedo	Segment
	Lead (Pb)					Nickel (Ni)				
Total	0.962**	0.926*	0.945**	0.902**	0.926**	0.722	0.959**	0.920**	0.981***	0.907**
DTPA-extractable		0.827*	0.917**	0.869*	0.927**		0.834*	0.900**	0.803*	0.670
Leaf			0.927**	0.936**	0.931**			0.969***	0.984***	0.888**
Flavedo				0.969**	0.939**				0.942**	0.916**
Albedo					0.957**					0.891*
	Cobalt (Co)					Cadmium (Cd)				
Total	0.718	0.131	0.891**	-0.537	0.302	-0.019	0.817*	0.040	-0.305	-0.517
DTPA-extractable		-0.422	-0.548	0.010	0.125		-0.294	-0.255	0.650	-0.612
Leaf			-0.414	-0.522	-0.092			0.312	-0.381	-0.391
Flavedo				0.562	-0.342				0.087	-0.238
Albedo					0.308					-0.385

Note: * p< .05; **p<.01; *** p< .001

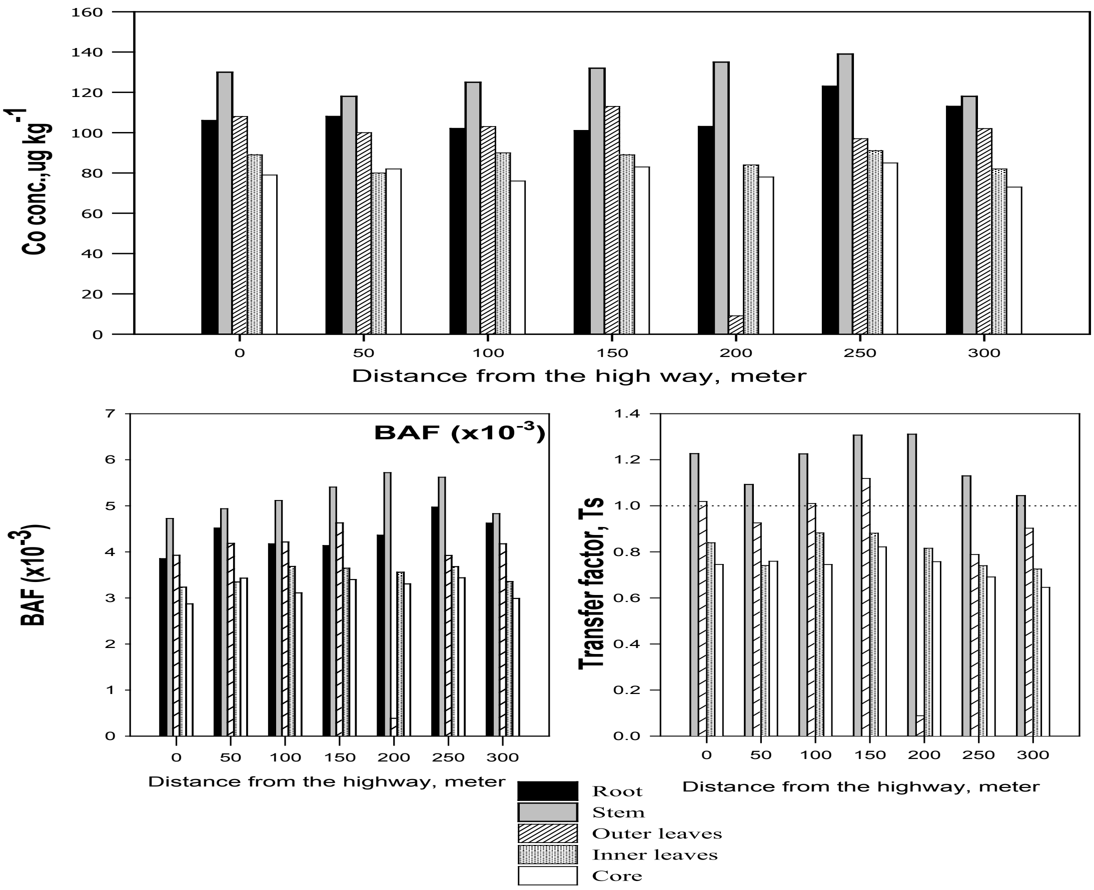

Fig. 7. Cobalt concentrations within the different parts of cabbage plants and the calculated biological accumulation factor (BAF) and transfer factors (Ts) as affected by the distance from the highway.

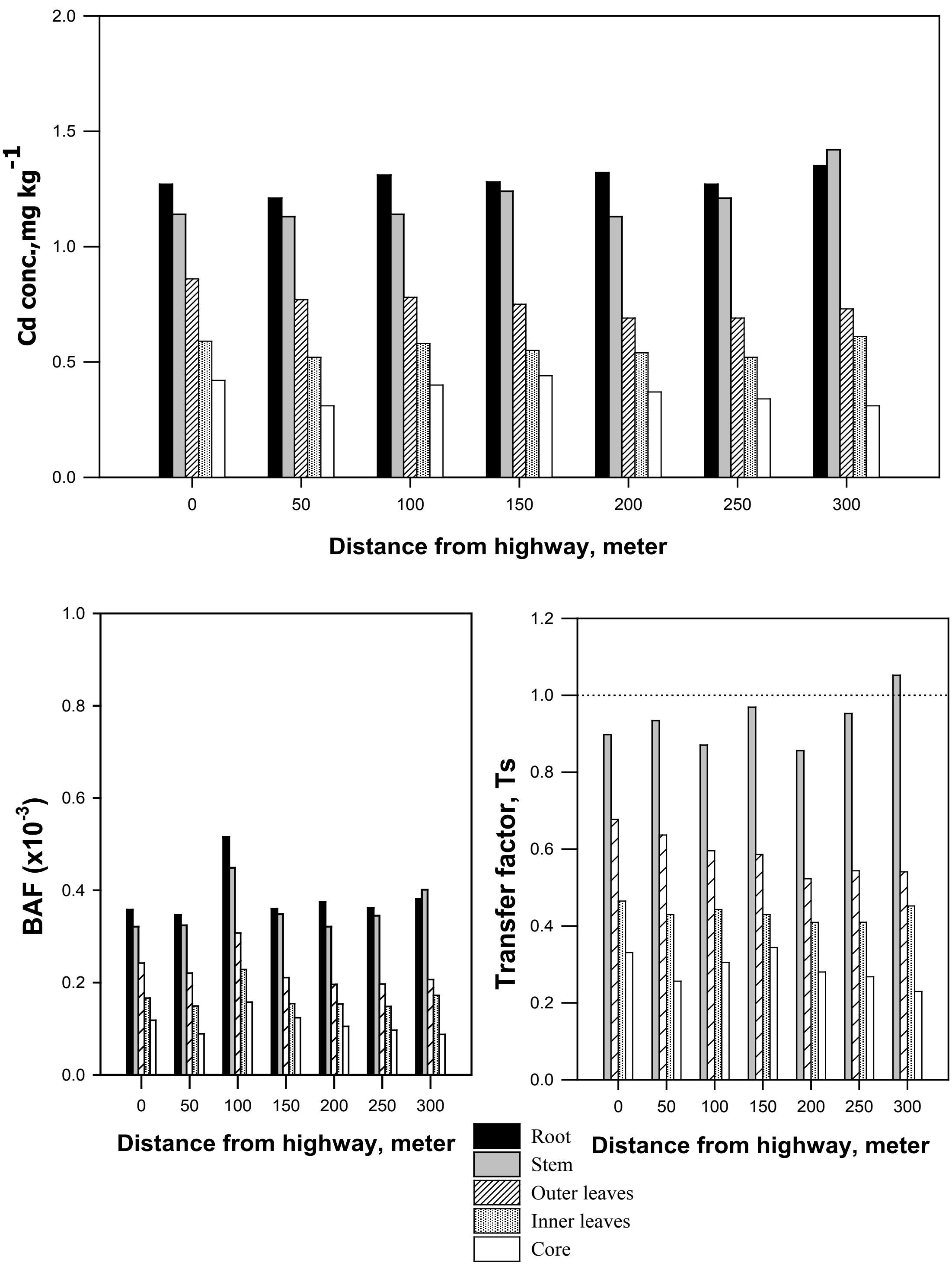

Fig. 8. Cadmium concentrations within the different parts of cabbage plants and the calculated biological accumulation factor (BAF) and transfer factors (Ts) as affected by the distance from the highway

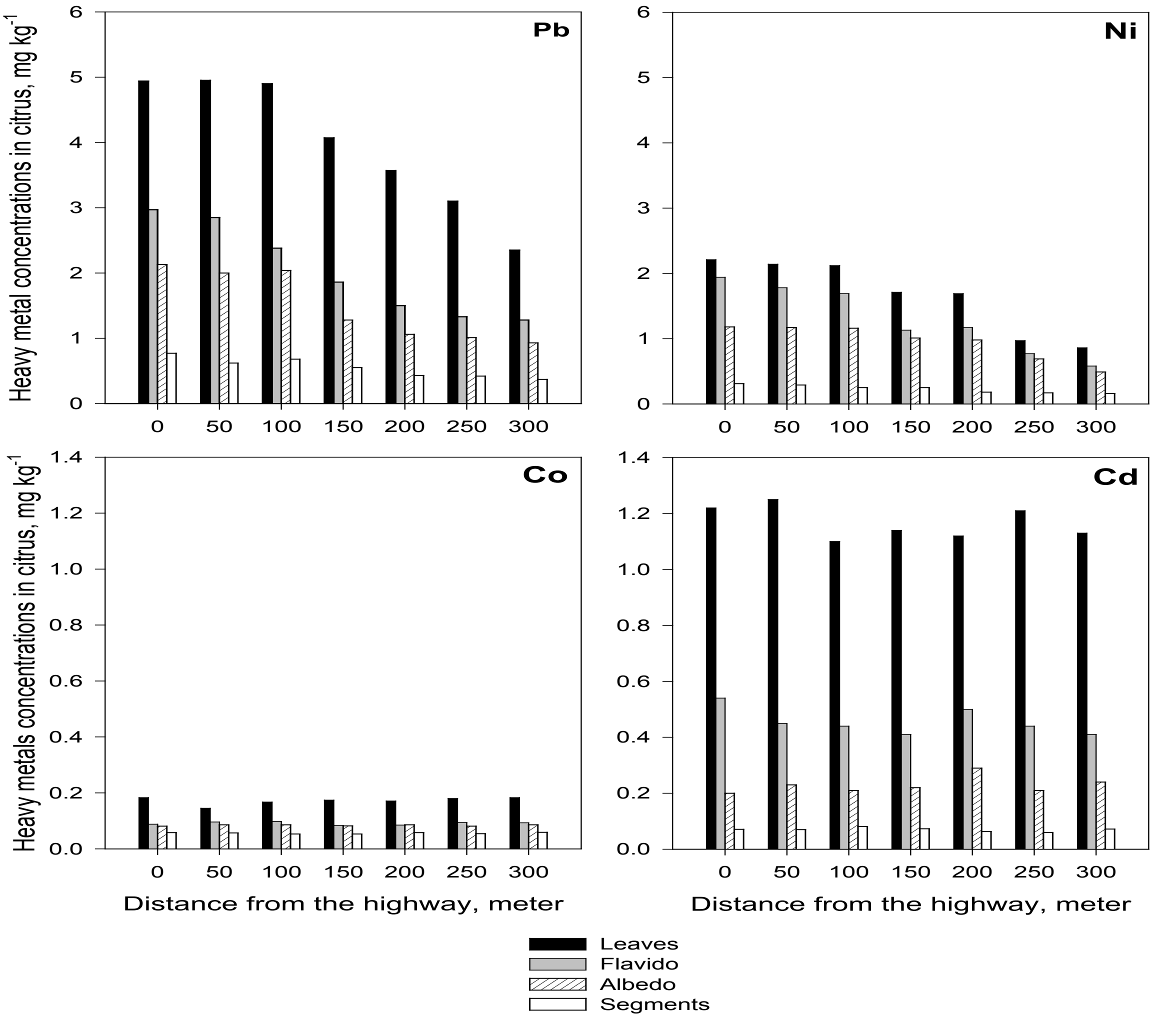

Fig. 9. Pb, Ni, Co and Cd concentrations within the different parts of citrus plants

Conclusion

High traffic on the highway near Toukh city increased progressively levels of soil contamination with Pb and Ni. Agricultural practices, which were carried out regularly on such soils, probably brought the contaminant to the subsurface layers of the soil at relatively high concentrations. These contaminants can't undergo degradation; therefore possess serious potential risk for both human and animal. Although, cabbage is an excluder plant for many heavy metals ,*i.e*. Pb, Co and Ni; however, carelessness in dealings with environmental problems for years had resulted in presence of high and, probably, toxic levels of these contaminants in plant parts. Cabbage accumulates high concentrations of Cd in its tissues. Accordingly, determining the level of Cd in the edible parts of cabbage should be considered within the main quality criteria of this product.

In citrus fruits, flavedo and albedo acted as natural defenders that lessened the amounts of heavy metals transferred from leaves to fruit segments. However, increasing levels of soil pollution of heavy metals must be taken into consideration. Concentrations of heavy metals in citrus leaves were relatively high and this might possess serious health problem in the near future.

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(*Received:*12/10/2016;
accepted: 5 / 2 /2017)

تراكم بعض العناصر الثقيله فى النباتات والأراضى المجاورة لطريق القاهره – الاسكندريه الزراعي السريع

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تعتبر عوادم السيارات المصدر الرئيسي لتلوث الهواء بالعناصر الثقيله ، و التي تتسبب في ظهور مشكلات بيئية خطيرة خاصة عند تراكمها في الأراضي الزراعية المجاورة بتركيزات مرتفعة، و بالتالى تهدف الدراسه التاليه الى تقييم مستويات تلوث الطبقة السطحية (0-15سم) من الأراضي الزراعية المجاورة للطريق الزراعى السريع بالرصاص،والنيكل، والكوبلت، والكادميوم و مدي انتقال تلك الملوثات إلي الطبقة التحت سطحيه(15-40سم)، وأثر ذلك علي امتصاص النبات النامي لتلك العناصر، وقد تم اختيار 7 مواقع للدراسه علي كل جانب من جوانب الطريق السريع عند مدينة طوخ، ويبتعد كل موقع عن الأخر مسافة 50 مترحيث تم تجميع عينات من التربة من الطبقات السطحية والتحت سطحية بالإضافة إلي عينات نباتية من الكرنب و الموالح النامية في تلك المناطق و قد أوضحت النتائج أن الأراضى موضع الدراسه ملوثه بالرصاص، والنيكل، و الكادميوم و هذه الملوثات انتقلت الى الطبقات التحت سطحيه من التربه بتركيزات مرتفعه كما أظهرت النتائج أن التركيز الكلي للرصاص و النيكل بالاضافه الى الكميات المستخلصه بواسطة DTPA تناقصت على جانبى الطريق بالبعد عن الطريق السريع و ارتبط تركيز تلك العناصر فى أجزاء الكرنب المختلفه بالتركيز الكلي والميسر لتلك العناصر في التربة، كما أظهرت النتائج أن تركيزات الكوبلت و الكادميوم فى التربه لم تتأثر بعوادم السيارات على الطريق السريع و بصفه عامه فقد تناقصت تركيزات تلك المعادن الثقيله فى الأجزاء النباتيه المختلفه من الكرنب على النحو التالي : الجذر> الساق> الأوراق الخارجيه> الأوراق الداخليه> القلب و بالنسبه لمعامل التراكم الحيويBAF للرصاص و النيكل و الكوبلت فكانت القيم المحسوبة منخفضه جدا بينما كان معامل انتقال تلك المعادن Ts من الجذور الى الأوراق مرتفع . و بالنسبه للموالح فقد تناقص تركيز المعادن الثقيله على النحو التالى : الأوراق> القشره الخارجيه> القشره الفلينيه> الفصوص و بصفه عامه وجد أن تركيز المعادن الثقيله موضع الدراسه فى النبات قد تجاوزت الحدود المسموح بها خاصه بالنسبه لعنصر الرصاص.