Egypt. J. Soil Sci. **Vol. 60**, No. 3, pp. 337 - 354 (2021)

Egyptian Journal of Soil Science

http://ejss.journals.ekb.eg/

Evaluation of Heavy Metals Concentration as Affected by Vehicular Emission in Alluvial Soil at Middle Egypt Conditions

Mohamed G.R. Sarhan[1], Ahmed M.Abd Elhafeez[2], and SamahO. Bashandy[3]

[1]*Soil, Water and Environment Res. Inst., Agricultural Research Center, Egypt*
2 Soil and Water Sci. Dep., Fac., of Agric., Beni-Suef Univ. Egypt
3 Soil and Water Sci. Dep., Fac., of Agric., Minia University, Egypt

ROOD TRAFFIC exhaust emissions are one of the most common sources of contaminants to soils and vegetation lies in the vicinity of highways. The main aim of this research is to investigate concentrations of Pb, Cd, Zn and Cu in soil at surface soil depth (0.0 – 30) and subsurface soil depth (30 – 60 cm) as affected by vehicle exhausts along the agricultural highway connecting Cairo – El-Minia City across Beba City, Beni-Suef Governorate, Egypt. In addition, revising the consequences on the staple wheat and maize roadside crops in terms of heavy metals presence in the edible parts for animals and humans. The results show that as the distance from the road decreased the concentration of Pb, Cd and Zn increased to 22, 45, 67, in soils and to 34, 56, 67 in plants, respectively. In general, the limits of heavy metals in wheat and maize plants were safe as stated by WHO (World Health Organization), except Cd (34) in leaves of wheat and maize grown adjacent the road. The pollution incidences, namely, transfer factor (TF), single pollution index (PI) and index of geo-accumulation (Igeo) were calculated and the results indicate that these indices decreased as the distance from the road increased especially in the western side rather than the eastern one. In this concern, this soil was moderately contaminated with Cd, while Pb, Zn and Cu were in the safety level. In conclusion, wheat and corn leaves contain cadmium near the danger limit, so it can be concluded that feeding animals should be prevented by plants grown near highways.

Key Words: Heavy metals, Vehicular emission, Contamination, Alluvial soil, Wheat, Maize

Introduction

Soil contamination is the presence of contaminants into the soil ecosystem to a level that can affect negatively plants, soil micro-organisms, ground water quality and subsequently human health (Möller et al., 2005; Lone et al., 2008 and Abdelhafez et al., 2014 and 2021). 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 by biodegradation (Tangahu et al., 2011; Osman et al., 2017; Abbas and Bassouny, 2018; Elshazly et al., 2019; Shehata et al., 2019; and Farid et al.,

*Corresponding author e-mail: gmohamed78@yahoo.com.
Received: 4//8/2021; Accepted: 4/10/2021
DOI: 10.21608/ejss.2021.89288.1460

2020). Heavy metal spread widely as a result of anthropogenic activities and industrial revolution. Excess concentrations of heavy metals, exceeding the permissible limits, can cause a serious ecological disaster (Akguc et al., 2008 and Huseyinova et al., 2009), and severe health deterioration particularly to children (WHO, 1995). Heavy metals enter human bodies via different pathways causing potential health hazards and death (Abdelhafez et al., 2014).

The main sources of these heavy metals are: 1- urban industrial aerosol created by combustion of fuels metal or refining and other industrial processes, 2- liquid and solid wastes from animals and human beings, mining wastes, or 3- industrial and agricultural chemicals. Vehicular emissions are the most primary sources of soil pollution with heavy metals along roadsides (Yan et al., 2012). The numbers of vehicles are rapidly increased in the last three decades, which caused the increment in the pollution from vehicles emissions. The presence of heavy metals in higher content in the environment caused negative impacts on plants and animals thereon. In this concern, Zeng (2008) confirmed that, the roadside crops are contaminated as a result of increased traffic emissions, especially near the major highways.

Vehicular emissions are considered one of the main sources of heavy metal pollution ls in the surrounding agricultural areas nearby the highways (Hashem et al., 2016; Osman et al., 2017 and Shehata et al., 2019). Plants grown thereon absorb high concentrations of these contaminants from soil and; hence possess potential threats for main and animals feeding on these plants (Hashem et al., 2016). Accordingly, it is important to investigate the potential contaminants in the surrounding environment for prevalence of healthy food (Al-Fawwaz and Al-Khazaleh, 2017, Bettaib and Arbaoui, 2018. Shehata et al., 2019). Manganese, copper and zinc are essential nutrients needed for enzyme systems, especially, oxidation-reduction reactions as well as other important biochemical process (Akaninwor et al., 2006). On the other hand, mercury, lead, cadmium and arsenic are toxic even at very low concentration (Nkansah and Amoake 2010).

Some of these metals are used in manufacturing of alloys, wires, pipes and vehicle tires, e.g., Cu, Zn and Cd and may release to the surrounding environments near the highways due to mechanical corrosions and breakdowns (Jaradat et al., 2005). Heavy metals cause a great threat to the environment and public health if the levels go beyond admissible limits (Tudi et al., 2021). Cadmium, Chromium, Lead and Nickel are cumulative toxic heavy metals with features of high mobility and chemical activity, so availability for uptake by plants threaten safety of agricultural products and human health (Jadoon et al., 2021).

Moreover, Winther and Slento (2010) reported that the most important sources of lead and copper are the vehicle braking system corrosions as well as heated metal alloys used in the vehicle engines and gaseous emissions.

The vehicles fuels in Egypt were leaded since few years ago, consequently increased the contamination of soil, air and plants near the roadsides. The most common metal pollutions were arising as a result of increasing traffic activity includes Pb, Cd, Zn and Cu (according to the U.S. Government, 2001). In addition to in Egypt, sources of the agricultural soil contamination involve the utilization of contaminated agrochemicals, irrigation with saline and polluted groundwater, the reuse of drainage water, the recycling of wastewater, the polluted air, and the inappropriate disposing of solid wastes (Abd El-

Azeim et al., 2016). The toxicity of the heavy metals may cause metabolic disorders in plants and growth inhibition for most plant species (Sinha, 2005 and Hashim et al., 2017). Several investigations indicated that heavy metals are quite crucial for human health. But these heavy metals may become extremely toxic at higher concentrations. Wuana and Okieimen (2011) reported that copper toxicity may be resulted in kidney and liver damages, intestinal and stomach irritation and anaemia. As well, zinc toxicity may result in arteriole sclerosis and pancreatic complications and damages, consequently disturbing the body, protein metabolism (Yan et al., 2012). Furthermore, Pb, Cd metals may remain toxic under low levels, causing complications such as increased cancer risks (Willers et al., 2005; and Bassouny et al., 2020).

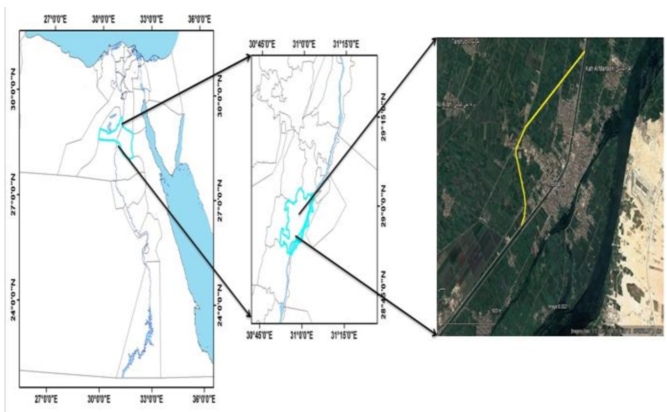
In recent years, numerous soil and plant heavy metal contamination valuation methods have been developed, involving the index method. At present, the Hakanson index method is the most scientific and comprehensive approach to assess heavy metal contamination in soils (Wang et al., 2013). Other indices like geo-accumulation index (Igeo), pollution index (PI), contamination index (CI), enhancement factor (EF), have also been broadly used to determine the soil metal contamination (Diop et al. 2015 and Sahu et al., 2021). Transformation factor (TF) is one of the main components which calculates the differences in bio-availability of heavy metals to plants from the soil rhizosphere, and to identify the efficacy of the plant to cumulate the given metal. Heavy metals have the capability to translocate from soil to the plant parts and can be determined by the transfer factor (TF) (Kumar et al., 2020).

The main aim of this research is to investigate concentrations of Pb, Cd, Zn and Cu in soil at surface soil depth (0.0 – 30) and subsurface soil depth (30 – 60 cm) as affected by vehicle exhausts along the agricultural highway connecting Cairo – El-Minia City across Beba City, Beni-Suef Governorate, Egypt. In addition, revising the consequences on the staple wheat and maize roadside crops in terms of heavy metals presence in the edible parts for animals and humans.

Material and Methods

The study area

The area under investigation is located at Cairo-El-Minia agricultural highway, in the ring road around Beba City district, about 25 km south Beni-Suef City (Map 1). The Beni-Suef Governorate is situated at 28º55'18"N, 30º59'04"E with an elevation of 30-40 m above sea level. To investigate effects of vehicle exhausts on soil and plant contamination with heavy metals, a survey study was conducted for two successive years (two winter seasons and 2 summer ones). In this study, surface (0-30 cm) and subsurface (30-60 cm) soil samples were collected at six different sites (per season) from both sides of the highway with 40 m apart among these sites, starting from locations nearby the agricultural highway up to 270 m apart from this road.



Map (1): Study area map and area close-up

Plant samples were collected from wheat (a winter crop at 2018/2019 and 2019/2020) and also from maize as a summer crop (2019 and 2020) from six abovementioned locations. Soil samples were dried at 60 ºC and sieved to 2 mm, where some physicochemical properties (according to A.O.A.C, 1990) were determined and listed in Table 1. Moreover, in these soil samples, DTPA extractable Zn, Cu, Pb and Cd were carried out by using 0.005 M DTPA, 0.1 M TEA and 0.01 M CaCl at pH 7.3. The soil solution ratio was 1:2 and the shaking time was 2 hours (Lindsay and Norvel, 1978). Also, aqua regia extracts were used to determine pseudo total soil metals (ISO 11466, 2002), where, 3 g of soil samples were deposited in a digester and made to react with 21 mL of HCl and 7 mL of HNO_3 for 16 h at ambient temperature and for 2 h at 130 ºC. For the extraction process, reaction containers with reflux condensers were used to prevent the loss of volatile elements. Then the samples were cooled at the ambient temperature and filtered using ashless paper before being diluted to a volume of 100 mL with 0.5 N HNO_3. The extractable solution for the two extractable methods was analysed using Atomic Absorption Spectrophotometer 210VGP.

Plant samples of both wheat and maize (leaf samples collected at booting and sulking stages, respectively) were divided into unwashed and washed portions. The washed portion was performed by 0.1 N HCl followed by distilled water to remove HCl. Also, grains and straw samples for both crops were taken from each plant. Plant materials (0.5g) were digested with a mixture of concentrated H_2SO_4, HNO_3 and $HClO_3$ (A.O.A.C., 1990). The studied heavy metals were determined by Atomic Absorption Spectro-photometer 210VGP.

TABLE 1. Some physicochemical properties of the investigated soils

locations	Distance (m)	Depth (cm)	Seasons	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Texture grade	pH (1:2.5 soil-water suspension)	EC, soil paste extract (dS m^{-1})	Organic matter g kg^{-1}	CaCO3 g kg^{-1}
West side	1-30	0.0-30	1st	1.10	17.00	29.02	52.88	Clay (Entisols)	7.84	1.25	23.3	24.9
			2nd	1.17	16.25	29.93	52.65		7.89	1.41	22.2	27.3
		30-60	1st	1.24	19.01	26.17	53.58		7.94	1.09	18.3	25.1
			2nd	1.29	18.63	25.85	54.23		7.91	1.17	17.7	27.6
	30-90	0.0-30	1st	1.10	17.81	28.08	53.01		7.91	1.31	23.9	25.2
			2nd	1.19	18.23	27.20	53.38		7.87	1.38	23.8	27.6
		30-60	1st	1.28	20.65	25.99	52.08		7.88	1.09	19.4	25.1
			2nd	1.36	19.96	25.19	53.49		7.90	1.43	18.4	27.7
	90-270	0.0-30	1st	1.09	17.17	28.45	53.29		7.89	1.28	23.9	24.9
			2nd	1.28	18.30	27.25	53.17		7.87	1.42	22.9	26.7
		30-60	1st	1.23	19.78	25.67	53.32		7.64	1.08	19.5	25.0
			2nd	1.41	19.68	24.76	54.15		7.91	1.16	18.8	26.8
East side	1-30	0.0-30	1st	1.32	18.31	27.31	53.06	Clay (Entisols)	7.88	1.29	22.3	22.6
			2nd	1.49	16.84	25.56	58.11		8.00	1.47	21.1	24.3
		30-60	1st	1.43	20.02	25.30	53.25		7.93	1.02	15.7	22.7
			2nd	1.60	18.53	20.91	58.96		8.03	1.40	13.7	24.1
	30-90	0.0-30	1st	1.30	19.66	26.32	52.72		7.96	1.28	22.1	23.6
			2nd	1.45	18.41	24.67	55.47		7.96	1.44	20.9	23.7
		30-60	1st	1.41	21.97	24.05	52.57		8.00	1.22	16.1	23.7
			2nd	1.56	20.37	22.88	55.19		8.01	1.38	13.6	24.0
	90-270	0.0-30	1st	1.30	19.72	26.24	52.74		7.97	1.28	12.2	22.2
			2nd	1.56	18.82	23.37	56.25		7.99	1.45	21.4	24.2
		30-60	1st	1.42	22.81	24.29	51.48		8.01	1.25	15.4	22.2
			2nd	1.56	20.70	21.65	56.09		8.03	1.40	13.9	23.8

Data handling

1- Transfer factor (TF)

Transfer factor (TF) of metals from agricultural soils to wheat and maize of metals Pb, Cd, Zn and Cu from soils to plants were calculated (Equation 1, Cui et al. 2004).

$$T.F. = \frac{Metal conc. in plant tissue (dry wt.)}{Total metal conc. in the soil (dry wt.)} \qquad (1)$$

The surface soil (0 – 30) was concerned in this study, because wheat and maize having root length not more than 30 cm.

2- The single-factor pollution index (PI)

The single-factor pollution index was calculated using the following formula (Zheng et al. 2006):

$$PI = {Ci}/{Si} \quad (2)$$

Where PI represents the single-factor pollution index of the pollutant in the soil, Ci is the concentration of soil heavy metal *i*, and Si the threshold of the pollutant *i* (Table 2).

3- Index of geo-accumulation (Igeo)

Index of geo-accumulation (Muller et al., 1971) was applied to assess the degree of soil pollution with heavy metals in this study. This method is used because it is a useful tool for the prediction of soil pollution and had been used by many authors as Sarkar et al. (2014), Zheng et al. (2015) and Milicevic et al. (2017).

$$Igeo = \log 2 \{\frac{Cm}{1.5\, xBm}\} \quad (3)$$

Where Cm is the measured concentration of the examined metal (m) in the soil samples and Bm is the geochemical background value of the same metal (m). The constant 1.5 is used for the possible variations of the background data due to the lithogenic effects. The background reference in this study is based on the world soil average abundance of metals (Pb = 20, Cd = 0.3, Zn = 95 and Cu = 50.

TABLE 2: Environmental quality standard for soils (The Editor-in-Chief of China Standard Press, 1996)

Item	Background values of natural soil	The second criterion of Environmental Quality Standard for Soils		
		pH<6.5	pH 6.5–7.5	pH>7.5
Pb	35.0	250.0	300.0	350.0
Cd	0.20	0.30	0.30	0.60
Zn	100.0	200.0	250.0	300.0
Cu	35.0	50.0	100.0	100.0

Statistical analysis

The obtained data were statistically analyzed by analysis of variance according to method described by Snedecor and Cochran (1980). Duncan's multiple range for comparing the differences between treatment means was used at the probability level of 0.05.

Results and Discussion

Soil properties

All studied soil samples were clay in texture, slightly alkaline in reaction (pH values ranged between 7.80-8.05), their salinity was having low content of calcium carbonate and organic matter. In general, the surface layers (10-30 cm) contained higher amounts of saline and organic matter than the subsurface 30-60 layers.

Pb, Cd, Zn and Cu content in soil

It can be seen from the data in Tables (3 and 4) and Figures (1, 2, 3 and 4) that the DTPA extraction and total studied heavy metals content decreased as the distance from the main road increased, except for copper which did not affect by the distance. Also, it can be notice that the concentration of heavy metals was higher in surface layers than in sub-surface ones. Moreover, concentrations of heavy metals in the eastern side of the road were higher than in the western side. In this concern, Harrison et al. (1981) mentioned that the heavy metals pollutants from the air eventually precipitate and accumulate on the land surface. Also, wind flow and its pattern determine the receipted content. The mean values of concentrations of the studied heavy metals can be arranged in the following decreasing order: Zn > Pb > Cu > Cd. Obviously, the levels of Zn were higher, whereas the Cd values were the lowest. The grand mean overall the two seasons and two crops of DTPA-extractable Pb, Cd, Zn and Cu in western side of the road were 0.47. 0.17, 1.83 and 0.74 in surface soil and 0.37, 0.14, 1.74 and 0.64 µgg^{-1}in sub-surface soil µgg^{-1}. The corresponding values of the eastern side were 0.53, 0.20, 1.92 and 0.73 in the surface soil and 0.41, 0.16, 1.68 and 0.64 µgg^{-1}in sub-surface soil, respectively. However, the corresponding values of total Pb, Cd, Zn and Cu in western side were 14.96, 0.44, 53.99 and 10.18 in surface soil and 13.79, 0.41, 49.79 and 7.95 in sub-surface soil, while these values for eastern side were 15.82, 0.47, 57.80 and 10.16 in surface soil and 14.69, 0.44, 52.90 and 8.68 µgg^{-1} in sub-surface, respectively. The increment of heavy metals adjacent the main road may be due to the accumulation of these metals from the automobile exhausts on soil surfaces. Similar results were obtained by Yan et al. (2012) and Al-Fawwaz and Al-Khazaleh (2017). On the other hand, Kabuta-Pendias and Mukheryce (2007) mentioned that the concentration of copper, in topsoil or subsurface layers did not vary as affected by increasing the distances from the main road, because copper enters soil via different forms such as fertilizers, sprays and agricultural or municipal waste. On average the Earth's crust contain about 15 µgg^{-1} of Pb, where most soil adjacent the main road, especially topsoil is containing Pb more than 15 µgg^{-1} which is owing to an anthropogenic pollution. These results are in line with those obtained by Tume et al. (2006) and Bech et al. (2008). Furthermore, the incrementation of heavy metal concentrations in the eastern side was higher than in the western side of the road due to winds direction which is mainly blowing from west toward the east direction. In general, according to criteria report by Ross (1994) and Singh and Steinnes (1994) in Table (4), the concentration of the four studied heavy metals did not reach the toxic level.

TABLE 3.Concentration of aqua riga-extractable (Total form) Pb, Cd, Zn and Cu in soil samples used in the study

Plants	Location	Distance (m)	Depth (cm)	Pb (µgg^{-1})		Cd (µgg^{-1})		Zn (µgg^{-1})		Cu (µgg^{-1})	
				1st	2nd	1st	2nd	1st	2nd	1st	2nd
Wheat	Western side	1-30	10-30	17.32 a	17.37 a	0.54 a	0.54 a	67.41 a	69.33 a	10.06 a	10.22 a
			30-60	15.66 a	15.96 a	0.51 a	0.52 a	64.97 a	66.17 a	8.91 a	8.84 a
		30-90	10-30	14.61 b	15.62 b	0.43 b	0.46 b	48.36 b	51.65 b	10.17 a	10.17 a
			30-60	13.09 b	13.71 b	0.41 b	0.43 b	46.76 b	48.04 b	8.92 a	8.84 a
		90-270	10-30	12.20 c	13.20 c	0.35 c	0.37 c	40.41 c	42.73 c	10.16 a	10.18 a
			30-60	11.64 c	12.64 c	0.32 c	0.34 c	38.78 c	38.57 c	8.90 a	8.82 a
	Eastern side	1-30	10-30	18.15 a	18.22 a	0.57 a	0.54 a	70.58 a	73.63 a	10.12 a	10.19 a
			30-60	16.25 a	17.16 a	0.55 a	0.54 a	67.35 a	69.20 a	8.90 a	8.84 a
		30-90	10-30	15.08 b	15.26 b	0.47 b	0.46 b	50.65 b	56.33 b	10.14 a	10.15 a
			30-60	13.73 b	14.36 b	0.45 b	0.45 b	49.53 b	52.60 b	8.90 a	8.84 a
		90-270	10-30	13.30 c	14.07 c	0.41 c	0.40 c	42.10 c	48.46 c	10.12 a	10.15 a
			30-60	11.99 c	12.54 c	0.38 c	0.37 c	41.19 c	43.36 c	8.91 a	8.81 a
Maize	Western side	1-30	10-30	17.42 a	16.89 a	0.50 a	0.51 a	64.21 a	66.79 a	10.18 a	10.27 a
			30-60	15.34 a	16.30 a	0.47 a	0.49 a	59.37 a	63.56 a	8.16 a	8.86 a
		30-90	10-30	14.28 b	15.06 b	0.41 b	0.43 b	47.69 b	51.25 b	10.17 a	10.22 a
			30-60	12.43 b	14.81 b	0.38 b	0.41 b	44.60 b	48.54 b	8.13 a	8.88 a
		90-270	10-30	12.05 c	13.55 c	0.34 c	0.37 c	39.64 c	43.13 c	10.15 a	10.21 a
			30-60	11.25 c	13.23 c	0.31 c	0.34 c	37.71 c	40.37 c	8.12 a	8.87 a
	Eastern side	1-30	10-30	19.42 a	17.93 a	0.60 a	0.53 a	67.54 a	72.57 a	10.13 a	10.21 a
			30-60	18.41 a	16.15 a	0.53 a	0.50 a	62.40 a	68.59 a	8.14 a	8.80 a
		30-90	10-30	15.26 b	15.39 b	0.44 b	0.44 b	51.01 b	54.42 b	10.13 a	10.23 a
			30-60	14.23 b	15.07 b	0.41 b	0.41 b	46.55 b	51.23 b	8.13 a	8.88 a
		90-270	10-30	13.39 c	14.31 c	0.36 c	0.38 c	42.92 c	46.25 c	10.13 a	10.21 a
			30-60	12.41 c	13.97 c	0.34 c	0.36 c	39.37 c	42.90 c	8.12 a	8.83 a

TABLE 4. Average concentrations (mg/kg, dry mass, dm) of metals detected in agricultural soils, maximumallowable concentrations (MAC) in soil and toxic soil for plants

Metal	Mean concentration (mg/kg, dm) in soil		*MAC (mg/kg, dm)	*Toxic soil for plants (mg/kg, dm)
	Wheat	Maize		
Pb	18.22	19.42	20	100-400
Cd	0.57	0.60	0.3	3-8
Zn	73.63	72.57	300	70-400
Cu	10.22	10.27	100	60-125

*(Ross 1994; Singh and Steinnes 1994).

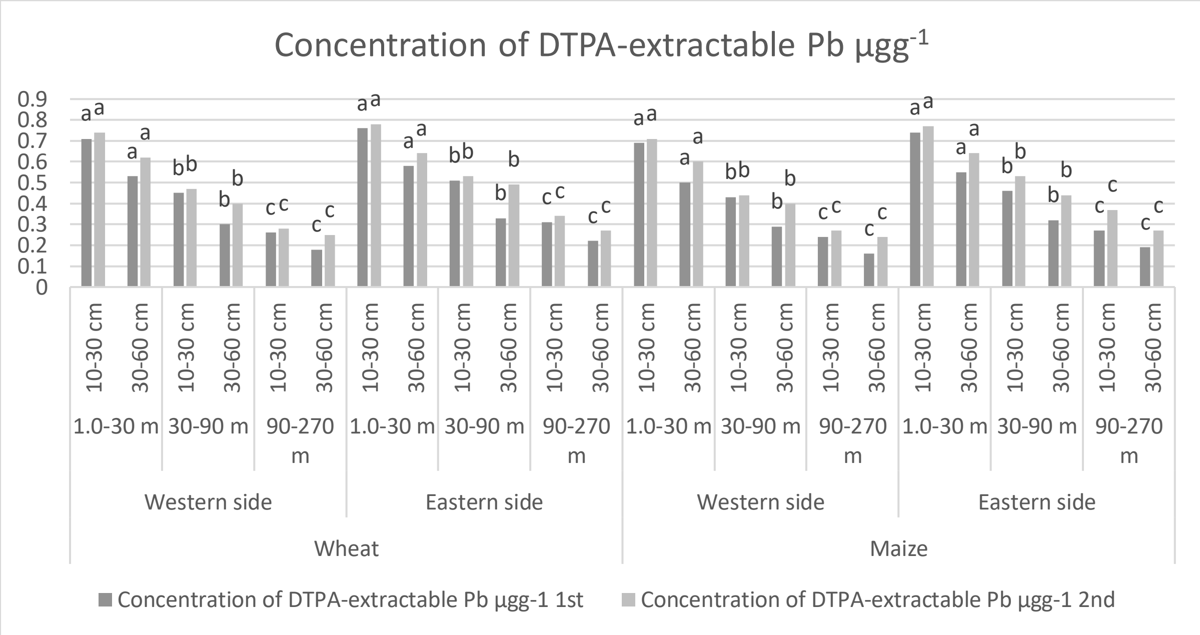


Fig. 1. Concentration of DTPA-extractable Pb in soil samples used in the study

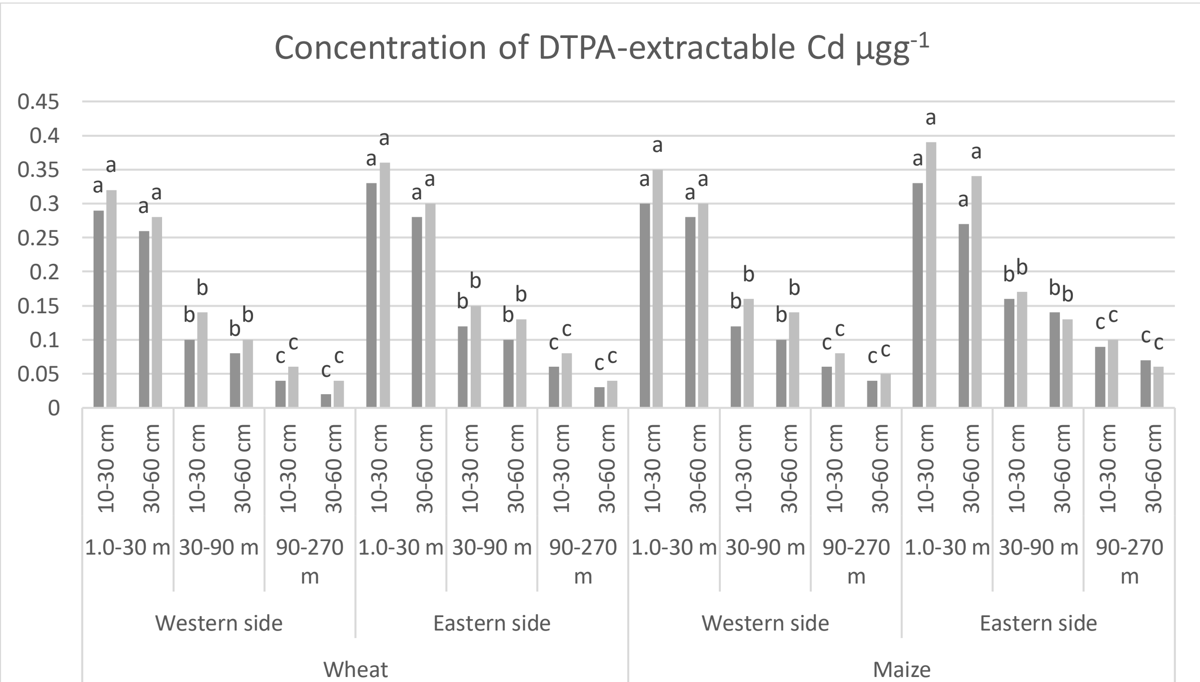


Fig. 2. Concentration of DTPA-extractable Cd in soil samples used in the study

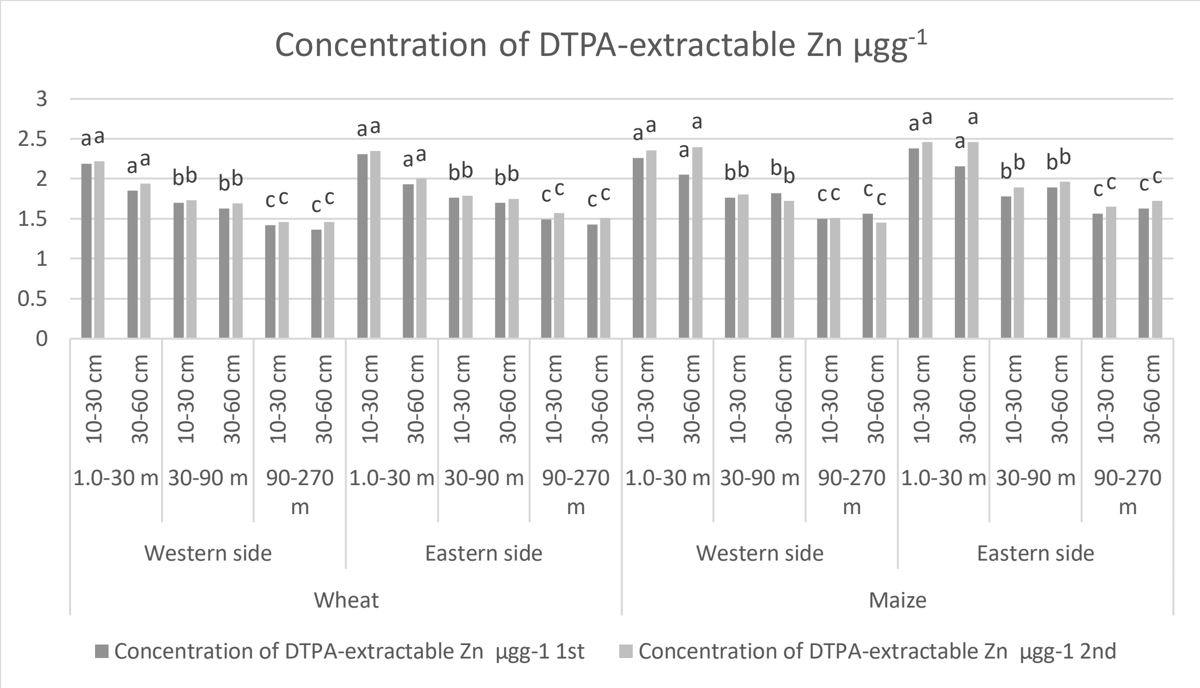


Fig. 3. Concentration of DTPA-extractable Zn in soil samples used in the study

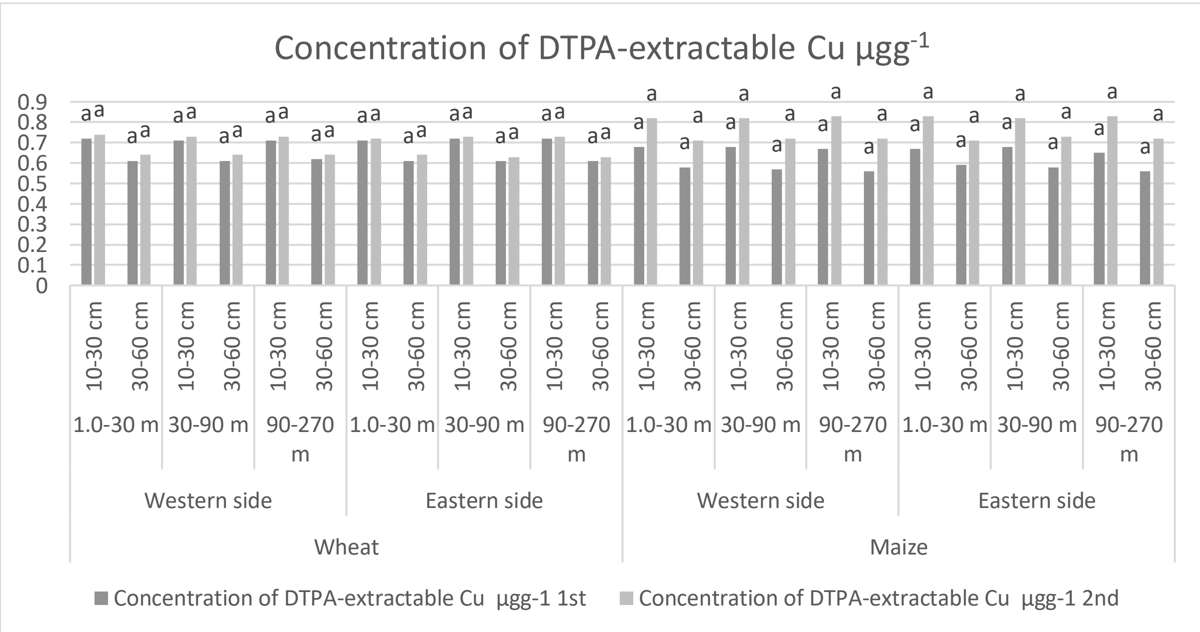


Fig. 4.Concentration of DTPA-extractable Cu in soil samples used in the study

Wheat and maize growth, yield components

Data in Table 5 indicate that all studied wheat and maize growth parameters and yield components were significantly higher by increasing the distance from the main road. The nearer the plants to the main road, the lowest values were the wheat and maize growth and yield component parameters. In this concern, the reductions in plant height, dry weight, number of spikes m^{-2}, number of grains spike^{-1} and 1000-grain weight for wheat plants grown at one meter apart from the main road in the western side were 18.71, 17.83, 16.72, 10.69 and 4.61% when compared with those attained at 300m apart from the road, respectively in the first season. Similar trendswere obtained in the second season and in the eastern side of the road as well as for maize plants. This decrement in wheat and maize growth grown at area nearby the road is mainly affected by vehicular emissions, which emits heavy metals to the surrounding environment. These results reveal that heavy metals exhibited adverse effects on plant growth. Similar results were obtained by Aliu et al (2013), Tuna et al (2015) and Al-Fawwaz and Al-Khazaleh (2017).

TABLE 5. Some growth parameters and yield components of plants as affected by vehicular emissions

Plants	Location	Distance (m)	Plant height (cm)		Dry weight Plant^{-1} (g)		Number of spike m^{-2}		Number of grains spike^{-1}		1000-grain weight (g)	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Wheat	Western Side	1-30	27.15 b	27.87 b	2.12 b	2.18 b	370.30 c	373.30 c	38.70 b	39.17 b	49.67 c	49.80 c
		30-90	31.56 a	32.65 a	2.51 a	2.56 a	416.73 b	387.20 b	41.77 a	42.17 a	51.37 b	51.53 b
		90-270	33.40 a	34.42 a	2.58 a	2.62 a	444.63 a	447.23 a	43.33 a	43.63 a	52.07 a	52.27 a
	Eastern Side	1-30	25.28 b	26.29 b	1.96 b	2.00 b	365.56 c	368.10 c	38.53 b	38.63 b	49.50 c	49.63 c
		30-90	29.50 a	30.92 a	2.32 a	2.36 a	414.53 b	415.33 b	41.57 a	41.67 a	51.13 b	51.27 b
		90-270	31.53 a	32.09 a	2.45 a	2.48 a	435.13 a	439.23 a	43.47 a	44.03 a	51.90 a	52.13 a
			Plant height (cm)		Dry weight Plant^{-1} (g)		Number of row/ear		Number of grains row^{-1}		1000-grain weight (g)	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Maize	Western Side	1-30	139.39 c	138.63 c	86.00 b	85.64 b	12.64 a	12.61 a	45.34 b	45.28 b	27.82 b	27.80 b
		30-90	164.85 b	163.36 b	88.56 a	88.17 a	12.95 a	12.91 a	46.15 a	46.13 a	30.03 a	30.01 a
		90-270	179.94 a	178.68 a	89.97 a	89.52 a	13.08 a	13.03 a	46.31 a	46.27 a	30.18 a	30.16 a
	Eastern Side	1-30	137.63 c	136.67 c	85.63 b	85.05 b	12.26 a	12.23 a	45.28 b	44.91 b	27.81 b	27.78 b
		30-90	156.25 b	155.22 b	88.21 a	88.05 a	12.66 a	12.63 a	46.13 a	46.10 a	30.01 a	29.99 a
		90-270	178.19 a	176.48 a	89.53 a	89.21 a	13.04 a	12.97 a	44.27 a	44.24 a	30.15 a	30.12 a

Pb, Cd, Zn and Cu content in wheat and maize tissues

Data in Tables 6 and 7 represent the content of Pb, Cd, Zn and Cu in washed and unwashed leaves and grains and straw of both wheat and maize plants as affected by the distance from the road. The results clearly show that heavy metals content in different studied wheat and maize organs, except copper increased as the distance from the road decreased, which are in parallel to heavy metals content in soil (Tables 3 and 4). Also, it could be observed that unwashed wheat and maize leaves contain more heavy metals than the washed ones, which means that a part of this heavy metal's pollution is by air. In this respect, Morsy (1990) reported that the greatest part of heavy metals deposits through air and stays on the surface while only a minor part can enter the plant through the stomata. Moreover, maize plants had higher contents of heavy metals than wheat. In general, it could be noticed that the pollution with heavy metals is still even as far as 100 m from the road.These results agree with those obtained by Jadoon et al. (2021) found that the lead content in Egyptian clover increased with adjoining the plants to Cairo-Alexandria agricultural main-road and the pollution is still perceptible even for as 100 m from the road. However, Hashim et al. (2017) stated that at least 40m around both sides of traffic roads are subjected to lead and cadmium pollution. Additionally, Pb and Cd are the pollutant heavy metals, which have a toxic effect for plants and humans and animals feeding on this plant. The lead and cadmium permissible levels in plants recommended by WHO (World Health Organization) are 2.0 and 0.34 µgg^{-1}, respectively (Cristea et al., 2016). Although Pb pollution had adverse effects on wheat and maize growth, On the other hand, wheat and maize plant leaves grown adjacent the road contains Cd higher than the safely limits (0.34 µgg^{-1}), which may

TABLE 6. Pb, Cd, Zn and Cu content (µgg^{-1}) in washed and unwashed plant leaves as affected by Vehicular emissions

Plants	Location	Distance (m)	Pb 1st	Pb 2nd	Cd 1st	Cd 2nd	Zn 1st	Zn 2nd	Cu 1st	Cu 2nd
			washed plants leave							
Wheat	Western side	1-30	1.04 a	1.02 a	0.26 a	0.23 a	72.37 a	67.07 a	31.40a	30.47a
		30-90	0.93 b	0.92 b	0.11 b	0.08 b	40.97 b	36.23 b	31.20a	29.73a
		90-270	0.85 c	0.83 c	0.06 c	0.04 c	31.07 c	27.27 c	31.53a	29.60a
	Eastern side	1-30	1.09 a	1.07 a	0.31 a	0.27 a	81.03 a	71.50 a	31.37a	29.80a
		30-90	0.98 b	0.96 b	0.16 b	0.14 b	50.00 b	40.50 b	31.30a	29.80a
		90-270	0.86 c	0.84 c	0.11 c	0.08 c	40.63 c	32.17 c	31.53a	30.03a
Maize	Western side	1-30	1.17 a	1.15 a	0.29 a	0.25 a	82.80 a	77.37 a	40.43a	38.33a
		30-90	1.07 b	1.05 b	0.15 b	0.10 b	51.70 b	46.83 b	40.47a	38.60a
		90-270	0.98 c	0.95 c	0.08 c	0.05 c	36.27 c	32.17 c	40.40a	37.93a
	Eastern side	1-30	1.22 a	1.20 a	0.34 a	0.31 a	89.17 a	83.23 a	40.50a	38.30a
		30-90	1.11 b	1.09 b	0.18 b	0.16 b	58.53 b	53.10 b	40.37a	38.40a
		90-270	1.00 c	0.98 c	0.12 c	0.10 c	44.20 c	38.60 c	40.50a	38.30a
			unwashed plants leave							
Wheat	Western side	1-30	1.23 a	1.20 a	0.30 a	0.28 a	82.17 a	77.33 a	36.23a	35.03a
		30-90	1.11 b	1.09 b	0.16 b	0.15 b	51.80 b	46.43 b	36.03a	34.97a
		90-270	0.99 c	0.96 c	0.10 c	0.07 c	37.57 c	29.30 c	36.13a	35.00a
	Eastern side	1-30	1.28 a	1.25 a	0.36 a	0.33 a	86.70 a	78.87 a	36.40a	34.90a
		30-90	1.16 b	1.13 b	0.20 b	0.19 b	58.17 b	50.43 b	36.43a	35.00a
		90-270	1.06 c	1.00 c	0.12 c	0.09 c	46.97 c	38.63 c	36.50a	35.13a
Maize	Western side	1-30	1.57 a	1.56 a	0.40 a	0.37 a	93.90 a	88.17 a	43.63a	41.47a
		30-90	1.41 b	1.45 b	0.29 b	0.25 b	62.33 b	56.43 b	43.83a	41.80a
		90-270	1.25 c	1.25 c	0.19 c	0.14 c	41.27 c	35.23 c	43.87a	41.63a
	Eastern side	1-30	1.66 a	1.60 a	0.44 a	0.39 a	101.23 a	96.50 a	43.73a	41.57a
		30-90	1.47 b	1.42 b	0.26 b	0.21 b	68.57 b	63.67 b	43.73a	41.80a
		90-270	1.25 c	1.21 c	0.14 c	0.09 c	49.77 c	44.10 c	44.00a	43.13a

TABLE 7. Pb, Cd, Zn and Cu content (µgg^{-1}) in plants as affected by vehicular emissions

Plants	Location	Distance (m)	Pb 1st	Pb 2nd	Cd 1st	Cd 2nd	Zn 1st	Zn 2nd	Cu 1st	Cu 2nd
			Grains							
Wheat	Western side	1-30	0.92 a	0.88 a	0.19 a	0.17 a	60.6 a	57.83 a	19.33a	15.50a
		30-90	0.80 b	0.77 b	0.05 b	0.07 b	26.77 b	25.90 b	19.63a	15.70a
		90-270	0.73 c	0.71 c	0.01 c	0.03 c	6.10 c	5.77 c	19.80a	15.10a
	Eastern side	1-30	0.95 a	0.91 a	0.21 a	0.21 a	62.53 a	58.83 a	19.90a	15.63a
		30-90	0.80 b	0.77 b	0.05 b	0.07 b	26.77 b	25.90 b	19.63a	15.70a
		90-270	0.72 c	0.68 c	0.04 c	0.04 c	7.63 c	7.70 c	19.77a	15.07a
Maize	Western side	1-30	0.98 a	0.95 a	0.23 a	0.22 a	70.43 a	67.30 a	22.43a	19.47a
		30-90	0.84 b	0.81 b	0.09 b	0.08 b	40.97 b	37.70 b	22.43a	18.93a
		90-270	0.75 c	0.74 c	0.03 c	0.02 c	24.80 c	22.13 c	21.97a	19.27a
	Eastern side	1-30	0.99 a	0.97 a	0.25 a	0.24 a	75.47 a	71.51 a	21.80a	19.20a
		30-90	0.86 b	0.84 b	0.11 b	0.10 b	45.90 b	41.83 b	21.93a	18.57a
		90-270	0.80 c	0.77 c	0.04 c	0.03 c	29.47 c	24.13 c	22.33a	19.27a
			Straw							
Wheat	Western side	1-30	0.95 a	0.93 a	0.22 a	0.20 a	65.13 a	58.60 a	23.73a	21.77a
		30-90	0.84 b	0.81 b	0.08 b	0.06 b	31.93 b	26.87 b	23.83a	21.80a
		90-270	0.75 c	0.74 c	0.03 c	0.02 c	17.23 c	15.77 c	23.63a	21.50a
	Eastern side	1-30	0.98 a	0.95 a	0.25 a	0.23 a	69.93 a	57.93 a	23.97a	21.70a
		30-90	0.87 b	0.83 b	0.10 b	0.10 b	40.27 b	28.30 b	24.20a	22.00a
		90-270	0.77 c	0.72 c	0.04 c	0.04 c	23.77 c	12.77 c	23.77a	22.10a
Maize	Western side	1-30	1.12 a	1.11 a	0.24 a	0.23 a	76.73 a	73.97 a	24.50a	23.43a
		30-90	1.02 b	1.00 b	0.10 b	0.09 b	46.60 b	43.37 b	25.67a	23.33a
		90-270	0.93 c	0.91 c	0.04 c	0.02 c	30.53 c	27.37 c	25.60a	22.93a
	Eastern side	1-30	1.15 a	1.12 a	0.26 a	0.24 a	83.9 a	73.43 a	25.57a	23.50a
		30-90	1.04 b	1.01 b	0.12 b	0.10 b	52.87 b	40.47 b	25.60a	23.90a
		90-270	0.97 c	0.93 c	0.05 c	0.03 c	38.60 c	24.23 c	25.47a	23.40a

cause health hazardous for animals. As for Zn and Cu the data reveal that wheat and maize plants having Zn and Cu in different organs below the toxicity levels (the safe recommended limit of Zn and Cu in plants are 20 and 90.4 µgg^{-1}, WHO/FAO, 1984). These results are in harmony with those obtained by Igwegbe et al. (2013) and Latif et al. (2018).

Some pollution incidences

1. Transfer factor (TF) of Pb, Cd, Zn and Cu from soils to wheat and maize

Transfer factor is an important concept since heavy metals may have adverse effects on plants and animals as well as human that feeds on them. Transfer factor (TF) values reflect bioavailability of heavy metals whether for plants uptake or to be retained in soil (Nitu et al, 2019). The data of transfer factor of Pb, Cd, Zn and Cu for different organs of wheat and maize plants grown near the high way of Cairo-El Minia at Beba City are presented in Tables 8 and 9.

TABLE 8.Transfer factors (TF) of metals from agricultural soils to wheat plant

Plant organs	Location	Distance (m)	Transfer factors (TF) Pb		Cd		Zn		Cu	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd
Washed leaves	Western Side	1-30	0.06	0.06	0.48	0.43	1.07	0.97	3.12	2.98
		30-90	0.06	0.07	0.26	0.17	0.85	0.70	3.07	2.92
		90-270	0.07	0.06	0.17	0.11	0.77	0.64	3.10	2.91
	Mean		0.06	0.06	0.30	0.24	0.90	0.77	3.10	2.94
	Eastern Side	1-30	0.06	0.06	0.62	0.53	1.26	1.07	3.08	2.90
		30-90	0.07	0.06	0.39	0.33	1.05	0.79	3.07	2.92
		90-270	0.07	0.06	0.32	0.22	1.02	0.75	3.11	2.94
	Mean		0.07	0.06	0.44	0.25	1.11	0.87	3.08	2.92
Unwashed leaves	Western Side	1-30	0.07	0.07	0.56	0.52	1.22	1.12	3.60	3.43
		30-90	0.08	0.07	0.37	0.33	1.07	0.90	3.54	3.44
		90-270	0.08	0.07	0.29	0.19	0.93	0.69	3.56	3.44
	Mean		0.08	0.07	0.40	0.35	1.07	0.90	3.57	3.44
	Eastern Side	1-30	0.07	0.07	0.72	0.65	1.35	1.18	3.58	3.40
		30-90	0.08	0.08	0.49	0.44	1.22	0.98	3.58	3.42
		90-270	0.09	0.07	0.35	0.24	1.18	0.90	3.60	3.44
	Mean		0.08	0.07	0.52	0.44	1.25	1.02	3.59	3.42
Grain	Western Side	1-30	0.05	0.05	0.35	0.31	0.90	0.83	1.92	1.52
		30-90	0.05	0.05	0.12	0.15	0.55	0.50	1.93	1.54
		90-270	0.06	0.05	0.03	0.08	0.15	0.14	1.95	1.48
	Mean		0.05	0.05	0.17	0.18	0.53	0.49	1.93	1.51
	Eastern Side	1-30	0.05	0.05	0.42	0.41	0.97	0.88	1.95	1.52
		30-90	0.06	0.05	0.12	0.16	0.56	0.51	1.93	1.54
		90-270	0.06	0.05	0.12	0.11	0.19	0.18	1.95	1.48
	Mean		0.06	0.05	0.22	0.23	0.57	0.52	1.94	1.51
Straw	Western Side	1-30	0.05	0.05	0.41	0.37	0.97	0.85	2.36	2.13
		30-90	0.06	0.05	0.19	0.13	0.66	0.52	2.34	2.14
		90-270	0.06	0.06	0.09	0.05	0.43	0.37	2.33	2.11
	Mean		0.06	0.05	0.23	0.18	0.69	0.50	2.34	2.13
	Eastern Side	1-30	0.06	0.06	0.50	0.45	1.09	0.87	2.35	2.11
		30-90	0.06	0.06	0.24	0.23	0.79	0.59	2.38	2.15
		90-270	0.06	0.05	0.12	0.11	0.60	0.30	2.34	2.16
	Mean		0.06	0.06	0.29	0.26	0.83	0.59	2.36	2.14

The data indicate that Pb and Cd having low values of transfer factor for washed and unwashed leaves as well as grains and straw of wheat and maize plants in both seasons. It ranged between 0.05 to 0.08 for Pb and 0.09 to 0.65 for Cd for wheat plant and between 0.05 to 0.10 for Pb and 0.05 to 0.80 for Cd for maize plant in both seasons. On the other hand, Zn and Cu recorded the highest values of (TF) in both plants, which varied between 0.14 to 1.26, and 1.48 to 3.56 for wheat zinc and copper while the corresponding values for maize ranged from 0.30 to 1.50 and 1.85 to 4.32 for Zn and Cu, respectively. It can be notice that the transfer factor decreased as the distance from the road increased. Also, TF values in the eastern side were higher than in western side. Finally, the values of transfer factor greatly differ according to the plant organs, where it could be arranged the wheat or maize organs according to its TF values as the following descending order: unwashed leaves > washed leaves > straw ≥ grains. In this concern, Zurera et al (1987) mentioned that the mobility of metals to plants depended on soil physical and chemical properties, plant species, the environmental conditions and human activity. These results are in line with those obtained by Al Naggar et al (2014) and Nitu et al (2019). Moreover, Gupta et al (2013) notice that the leafy organs having TF higher than other plant tissues.

TABLE 9. Transfer factors (TF) of metals from agricultural soils to maize plant

Plant organs	Location	Distance (m)	Transfer factors (TF) Pb		Cd		Zn		Cu	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd
Washed Leaves	Western Side	1-30	0.06	0.06	0.52	0.45	1.13	1.00	3.08	2.97
		30-90	0.07	0.05	0.27	0.19	0.86	0.71	3.06	2.91
		90-270	0.07	0.06	0.18	0.11	0.78	0.63	3.11	2.90
	Mean		0.07	0.06	0.32	0.25	0.92	0.78	3.08	2.93
	Eastern Side	1-30	0.07	0.07	0.57	0.58	1.32	1.15	4.00	3.75
		30-90	0.07	0.07	0.41	0.36	1.15	0.98	3.99	3.75
		90-270	0.07	0.07	0.33	0.26	1.03	0.83	4.00	3.75
	Mean		0.07	0.07	0.44	0.40	1.17	0.99	4.00	3.75
Unwashed leaves	Western Side	1-30	0.09	0.09	0.80	0.73	1.46	1.32	4.29	4.04
		30-90	0.10	0.10	0.71	0.58	1.31	1.10	4.31	4.09
		90-270	0.10	0.09	0.56	0.38	1.04	0.82	4.32	4.08
	Mean		0.10	0.09	0.69	0.56	1.27	1.08	4.31	4.07
	Eastern Side	1-30	0.09	0.09	0.73	0.74	1.50	1.33	4.32	4.07
		30-90	0.10	0.09	0.59	0.48	1.34	1.17	4.42	4.09
		90-270	0.09	0.08	0.39	0.24	1.16	0.95	4.34	4.22
	Mean		0.09	0.09	0.57	0.49	1.33	1.15	4.33	4.13
Grain	Western Side	1-30	0.06	0.06	0.46	0.43	1.10	1.01	2.20	1.90
		30-90	0.06	0.05	0.22	0.19	0.86	0.74	2.21	1.85
		90-270	0.06	0.05	0.09	0.05	0.63	0.51	2.16	1.89
	M		0.06	0.05	0.26	0.22	0.86	0.75	2.19	1.88
	Eastern Side	1-30	0.05	0.05	0.42	0.45	1.12	0.99	2.15	1.88
		30-90	0.06	0.05	0.25	0.23	0.90	0.77	2.16	1.82
		90-270	0.06	0.05	0.11	0.08	0.69	0.52	2.20	1.89
	Mean		0.06	0.05	0.26	0.25	0.90	0.76	2.17	1.86
Straw	Western Side	1-30	0.10	0.07	0.48	0.45	1.19	1.11	2.45	2.28
		30-90	0.07	0.07	0.24	0.21	0.98	0.85	2.52	2.28
		90-270	0.06	0.05	0.11	0.11	0.60	0.30	2.34	2.16
	Mean		0.08	0.06	0.28	0.26	0.90	0.75	2.44	2.24
	Eastern Side	1-30	0.06	0.06	0.43	0.45	1.24	1.01	2.52	2.30
		30-90	0.07	0.07	0.27	0.23	1.03	0.74	2.53	2.34
		90-270	0.07	0.06	0.14	0.09	0.90	0.52	2.51	2.29
	Mean		0.07	0.06	0.28	0.26	1.06	0.76	2.52	2.31

2. Single pollution index (PI)

These parameters use to determine which heavy metal shows the highest threat on the surrounding ecosystem. It is expressed as the ratio between the concentration of heavy metal in the soil to the corresponding value of the second criterion environmental quality standard for soils, i.e., 350, 0.6, 300 and 100 for Pb, Cd, Zn and Cu, respectively. The data of the single pollution index for the studied heavy metals in the studied locations are given in Table (10). The data clearly show that the single pollution indexes for the four studied heavy metals were below one which means negligible risk of the effect of these heavy metals. Values of single pollution index can be arranged in the descending order as follow. Cd > Zn > Cu > Pb. Except Pb, the surface soil having (PI) higher than sub-surface soil. Also, single pollution index decreased as the distance from the road increased and in eastern side than the western side. It is worthy to notice that Cd exhibited the highest PI values (near to one), especially in the surface layer in western side. Therefore, more studies are needed to study the behaviour of Cd in such soils owing to the lower values of environment background value (0.6) and its high accumulation ability (Rabee et al., 2011). These results are in line with those obtained by Huang and Jin (2008) and Yang et al (2019).

TABLE 10.Single pollution index for the studied soil

plant	Location	Distance (m)	Depth (cm)	Single pollution index (PI) Pb 1st	Pb 2nd	Cd 1st	Cd 2nd	Zn 1st	Zn 2nd	Cu 1st	Cu 2nd
Wheat	Western Side	1-30	0-30	0.05	0.05	0.90	0.90	0.22	0.23	0.10	0.10
			30-60	0.04	0.05	0.85	0.87	0.22	0.22	0.09	0.09
		30-90	0-30	0.04	0.04	0.72	0.77	0.16	0.17	0.10	0.10
			30-60	0.04	0.04	0.68	0.72	0.16	0.16	0.09	0.09
		90-270	0-30	0.03	0.04	0.58	0.62	0.13	0.14	0.10	0.10
			30-60	0.03	0.04	0.53	0.57	0.13	0.13	0.09	0.09
	Eastern Side	1-30	0-30	0.05	0.05	0.95	0.90	0.24	0.25	0.10	0.10
			30-60	0.05	0.05	0.92	0.90	0.22	0.23	0.09	0.09
		30-90	0-30	0.04	0.04	0.78	0.77	0.17	0.19	0.10	0.10
			30-60	0.04	0.04	0.75	0.75	0.17	0.18	0.09	0.09
		90-270	0-30	0.04	0.04	0.68	0.67	0.14	0.14	0.10	0.10
			30-60	0.03	0.04	0.63	0.62	0.14	0.14	0.09	0.09
Maize	Western Side	1-30	0-30	0.05	0.05	0.83	0.85	0.21	0.22	0.10	0.10
			30-60	0.04	0.05	0.78	0.82	0.20	0.21	0.08	0.09
		30-90	0-30	0.04	0.04	0.68	0.72	0.16	0.17	0.10	0.10
			30-60	0.04	0.04	0.63	0.68	0.15	0.16	0.08	0.09
		90-270	0-30	0.03	0.04	0.57	0.61	0.13	0.14	0.10	0.10
			30-60	0.03	0.04	0.51	0.57	0.13	0.13	0.08	0.09
	Eastern Side	1-30	0-30	0.06	0.05	1.00	0.88	0.23	0.24	0.10	0.10
			30-60	0.05	0.05	0.88	0.83	0.21	0.23	0.08	0.09
		30-90	0-30	0.04	0.04	0.73	0.73	0.17	0.18	0.10	0.10
			30-60	0.04	0.04	0.68	0.68	0.16	0.17	0.08	0.09
		90-270	0-30	0.04	0.04	0.60	0.63	0.14	0.15	0.10	0.10
			30-60	0.04	0.04	0.57	0.60	0.13	0.14	0.08	0.09

3. Index of geo-accumulation (Igeo)

The index of geoaccumulation (Igeo) represents the levels and degree of heavy metal contamination in soils of the studied area (Singh, 2005). This incidence consists of seven grades, i.e., 1- uncontaminated (Igeo ≤ 0.0), 2- uncontaminated to moderately contaminated (0 < Igeo < 1), 3- moderately contaminated (1 < Igeo < 2), 4- moderately to strongly contaminated (2 < Igeo < 3), 5- strongly contaminated (3 < Igeo < 4), 6- strongly contaminated (4 < Igeo < 5), and 7- extremely contaminated (Igeo > 5). The data in Table (11) show the values of Igeo for the area adjacent Beni-Suef - El-Minia Road at Baba City.

TABLE 11. Geo accumulation index

Plants	Location	Distance (m)	Igeo Pb 1st	Pb 2nd	Cd 1st	Cd 2nd	Zn 1st	Zn 2nd	Cu 1st	Cu 2nd
Wheat	Western side	1-30	-0.79	-0.79	0.26	0.26	-1.08	-1.04	-2.90	-2.88
		30-90	-1.04	-0.94	-0.07	0.03	-1.56	-1.47	-2.88	-2.88
		90-270	-1.30	-1.18	-0.36	-0.28	-1.82	-1.74	-2.89	-2.88
	Eastern side	1-30	-0.73	-1.55	0.34	0.26	-1.01	-0.95	-2.89	-2.88
		30-90	-0.99	-0.98	0.06	0.03	-1.49	-1.34	-2.89	-2.89
		90-270	-1.17	-1.09	-0.13	-0.17	-1.76	-1.56	-2.89	-2.89
Maize	Western side	1-30	-0.78	-0.83	0.15	0.18	-1.15	-1.09	-2.88	-2.87
		30-90	-1.07	-0.99	-0.13	-0.06	-1.58	-1.48	-2.88	-2.88
		90-270	-1.32	-1.15	-0.40	-0.28	-1.85	-1.72	-2.89	-2.88
	Eastern side	1-30	-0.63	-0.74	0.42	0.24	-1.07	-0.97	-2.89	-2.88
		30-90	-0.98	-0.96	-0.03	-0.03	-1.4	-1.39	-2.89	-2.87
		90-270	-1.16	-1.07	-0.32	-0.24	-1.73	-1.62	-2.89	-2.88

Values of Igeo varied from metal to metal as well as the distance from the road and the side of location. The Igeo measurement decrease as the distance from the road increased. Moreover, these values increased in eastern side than western side. The variation in Igeo values is mainly due to the pollution from vehicular emission and to the main direction of wind is from west to east. Cd shows the highest values of Igeo, while Cu recorded the lowest one. In general, Igeo incidence reveal that Pb, Zn and Cu attain grade uncontaminated (Igeo $\leq$ 0.0) in all distances and locations. However, Igeo for Cd at near of the road in the two locations showed uncontaminated to moderately contaminated ($0 < \text{Igeo} < 1$), while the values of Igoe for Cd in the other distances attain uncontaminated grade. This suggested that the area under study was not polluted, except for Cd, near the road. These results reveal that this area is having background contamination for Pb, Cd, ZN and Cu and these heavy metals are unchanged by anthropogenic effects. Again, more attention must be paid to Cd pollution in this district to evaluate its contamination in this area, especially near the road owing to this metal having moderately contaminated near the road in the two locations. These results are inharmony with those obtained by Rabee et al (2011) and Salman et al (2018).

Conclusion

In this study, content of Pb, Cd, Zn and Cu were almost within the acceptable limits in plants as mentioned by W.H.O., except Cd content in plants adjacent the road. Pb, Cd and Zn content in soil whether total or soluble forms increased as the distance from the road decreased, consequently wheat and maize growth decreased. In conclusion, it can say that wheat and maize leaves contain Cd near the hazardous limit, therefore we should avoid feeding animals by plants grown nearer the road.

References

A.O.A.C. (1990). Official methods of Analysis. Association of Analytical chemists. Washinton D.C. **I**: 73-74.

Abbas, M.H.H. and M. Bassouny (2018) Implications of long-term irrigation with wastewater on the contents and retention kinetics of potentially toxic elements in Typic Tropopsamment soils. *Egypt J Soil Sci,* **58**(3), 337-357.

Abd El-Azeim, M. M.; W.S. Mohamed and A.A. Hammam (2016). Soil physiochemical properties in relation to heavy metals status of agricultural soils in Elmina governorate, Egypt. *J. Soil sci. And agric. Eng., Mansoura univ.*, vol. **7** (6): 423 - 431. Doi: 10.21608/issue. 2016.39676

Abdelhafez, A. A.; M. H. H. Abbas and T. M. S. Attia (2014). Environmental monitoring of heavy-metals status and human health risk assessment in the soil of Sahl El-Hessania area, Egypt. *Polish Journal of Environmental Studies,* **24** (2), 459-467.

Abdelhafez, A.A., M.H.H. Abbas, M.H.M. Kenawy, A. Noureldeen, H. Darwish, A.M.G. Ewis and M.H. Hamed (2021) Evaluation of underground water quality for drinking and irrigation purposes in New Valley Governorate, Egypt, *Environmental Technology & Innovation,***22**, 101486,

Akaninwor, J. O.; E. N. Onyeike and J. C. Ifemeje (2006). Trace metal levels in raw and heat processed Nigerian stable food from oil producing areas of rivers and Bayelsa States. *J. Applied Sci. Environmental Management.***10** (2); 23-27.

Akguc, N.; I. L. Özgiğit and C. Yarci (2008). Pyracantha Coccinea Roem, (Rosaceae) as a bio monitor for Cd, Pb and Zn in Muglia province

(Turkey). *Pakistan Journal of Botany*,**40** (4), 1767-1776.

Al-Fawwaz, A. T. and Al-Khazaleh (2017). Evaluation of Pb, Cu, Zn and Cd levels in some plants at roadsides between Mafraq and Jerash, Jordan. *J. of Environmental Sci. and Eng.***6**: 395-401.

Aliu, S.; B. Gashi; I. Rusinovei; Sh. Fetahu, and R. Vataj (2013). Effect of some heavy metals in some morpho-physiological parameters in maize seedlings. *American J. of Biochemistry and biotechnology*,**9**(1): 27-33.

Al-Naggar, Y.; E. Naiem, M. Mona et al (2014). Metals in agricultural soils and plants in Egypt. *Toxicological and Environmental Chemistry*,**96**(5): 730-742.

Bassouny, M. A.; M. H.H. Abbas, and I. Mohamed (2020). Environmental risks associated with the leakage of untreated wastewaters in industrial areas. *Egypt. J. Soil. Sci.* Vol. **60**, No. 2, pp. 109-128.

Bech, J.; P. Tume and L. Longan (2008). Concentration of Cd, Cu, Pb, Zn, Al and Fe in soils of Manresa, NE Spain. *J. Environ Monit Assess* **(145)**: 257-266.

Bettaieb, T. and S. Arbaoui (2018). Heavy metal accumulation in micro propagated plants of kenaf (Hibiscus cannabinus L.). *Int J Adv Sci Eng Technol***6**:32–33.

Cristea, T.; S. Alda; A. L. Maria; M. Diana; I. Gogoasa; S. Claudia; T. Alina, and B. D. Maria (2016). Researches on lead content in soil and Zea mays L. grains. *J. of Horticulture, Foresty and Biotechnology*,**20** (3): 51-54.

Cui, Y.; Y. Zhu; R. Zhai; D. Chen; Y. Huang; Y. Qui and J. Lian. (2004). “Transfer of Metals from Soil to Vegetables in an Area Near a Smelter in Nanning, China.” *Environment International***30**: 785_791.

Diop, C., Dewaelé, D., Cazier, F., Diouf, A. and Ouddane, B. (2015). Assessment of trace metals contamination level, bioavailability and toxicity in sediments from Dakar coast and Saint Louis estuary in Senegal, West Africa. *Chemosphere*,**138**, pp.980-987. https:// doi.org/ 10.1016/j.chemosphere.2014.12.041.

ElShazly, A.A., Abbas, M.H.H., Farid, I.M., Rizk, M., Abdelhafez, A.A., Abbas, H.H., Soliman, S.M., Abdel Sabour, M.F., Mohamed, I. (2019) Depth profile distribution of Cs and its toxicity for canola plants grown on arid rainfed soils as affected by increasing K-inputs.*Ecotoxicology and Environmental Safety*,**183**, 109529.

Farid, I. M.; M. H. H. Abbas; M. A. Bassouny; A. Gameel and H. H. Abbas (2020). Indirect impacts of irrigation with low quality water on the environmental safety. *Egypt. J. Soil. Sci.* Vol. **60**, No. 1, pp.1-15 (2020).

Gupta, S.; V. Jena; S. Jena et al (2013). Assessment of heavy metal content of green leafy vegetables. *Croation Journal of Food Science and Technology*,**5**(2): 53-60.

Harrison, R. M.; D. Laxen and S. J. Wilson (1981). Isolation and characterization of heavy metal resistant microbes. *Environ. Sci. Technol.***(15)**:1379-1383.

Hashim, T.A., H.H. Abbas, I.M. Farid, O.H.M. El-Husseiny and M.H.H. Abbas (2017) Accumulation of some heavy metals in plants and soils adjacent to Cairo – Alexandria agricultural highway. *Egypt. J. Soil Sci.***57** (2), 215- 232.

Huang, Sh. W and J. Y. Jin (2008). Status of heavy metals in agricultural soils as affected by different patterns of land use. *Environ. Monit. Assess.*,**139**: 317-327.

Huseyinova, R.; H. G. Kutbay; A. Bilgin, D. Kılıc, A. Horuz and C. Kirmanoğlu (2009) Sulphur and some heavy metals content in foliage of Corylus avellana and some road side native plants in Ordu province, Turkey. *Ekoloji***18** (70), 10-16.

Igwegbe, A. O.; C. H. Agukwe, and C. A. Negbenebor (2013). A survey of heavy metals (lead, cadmium and copper) contents of selected fruit and vegetable crops from borno state of Nigeria. *International J. of Eng. And Sci.*,**2** (1): 1-5.

ISO 11466 (2002). Soil quality: extraction of trace elements soluble in aqua regia. *International Organization for Standardization: Geneva.*

Jadoon, W.A., Abdel-Dayem, S.M.M.A., Saqib, Z., Takeda, K., Sakugawa, H., Hussain, M., Shah, G.M., Rehman, W. and Syed, J.H., (2021). Heavy metals in urban dusts from Alexandria and Kafr El-Sheikh, Egypt: implications for human health. *Environmental Science and Pollution Research,* **28**(2), pp.2007-2018. https://doi.org/ 10.1007/ s11356-020-08786-1

Jaradat, Q. M.; A. Masadeh; M. A. Zaitoun and B. M. Maitah (2005). Heavy metal contamination of soil, plant and air of scrapyard of discarded vehicles at Zarqa City, Jordan. *Soil, Sediment Contam.***14** (5):449-462.

Kabata-Pendias, A and A. B. Mukherjee (2007). Trace elements from soil to human. *Berlin: Springer.*

Kumar, A., Cabral-Pinto, M., Kumar, M. and Dinis, P.A. (2020). Estimation of Risk to the Eco-Environment and Human Health of Using Heavy Metals in the Uttarakhand Himalaya, India. *Applied Sciences*,**10**(20), p.7078. https://doi.org/10.3390/app10207078

Latif, A.; M. Bilal; W. Asghar; M. Azeem; M. I. Ahmad; A. Abbas; M. Z. Ahmad, and T. Shahzad (2018). Heavy metal accumulation in vegrtables and assessment of their potential health risk. *J. Environ. Anal Chem.*, **5** (1): 2380-2391.

Lindsay, W. L and W. A. Norvell (1978). Development of a DTPA test for soil Zinc, Iron, Manganese and Copper. *Soil Sci. Soc. Am. J.***(42)**: 421-428.

Lone, M. I.; Z. He, P. J. Stoffella and X. Yang (2008) Phytoremediation of heavy metal polluted soils and water: Progresses and perspectives. *J. Zhejiang Univ. Sci.* **B9** (3), 210–220.

Milicevic, T., Relic, D., Skrivanj, S., Tesic, Z. and Popovic, A. (2017). Assessment of major and trace element bioavailability in vineyard soil applying different single extraction procedures and pseudo-total digestion. *Chemosphere*,**171**, 284-293 (2017).

Möller, A.; H. W. Müller, A. Abdullah, G. Abdelgawad and Utermann, J. (2005). Urban soil pollution in Damascus, Syria: concentrations and patterns of heavy metals in the soils of the Damascus Ghouta. *Geoderma*,**124**(1–2), 63-71.

Morsy, M. A. (1990). Studied on pollution of some egyptian soils by heavy metals. *M. Sc. Thesis, Fac. of Agric., Minia University.*

Muller, G. (1971). Schwermetalle in den sedimenten des Rheins, Veranderungem Seit 1971, *Umschau*,**79**, 778–783 (1979).

Nitu, M.; A. Pruteanu; D. M. Bordean et al (2019). Researches on the accumulation and transfer of heavy metals in the soil in Tomatoes-Solanum lycopersicum. *EZS Web of Conferences,* **112**. 03020, TE-RE-RD.

Nkansan, M. A. and C. O. Amoako (2010). Heavy metal content of some common spicies available in markets in the Kumasi metropolis of Ghana. *American Journal of Scientific and Industrial Research.* **(192)**: 158-163.

Osman, M. E. H.; S. S. El-Feky, M. I. Elshahawy and E. M. Shaker (2017). Efficiency of flax (Linum usitatissimum L.) as a phytoremediator plant for the contaminated soils with heavy metals. *IJAER* **3**:3577–3600

Rabee, A. M.; Y. F. Al-Fatlawy; A. A. N. Abdown and M. Nameer (2011). Using pollution load index (PLI) and geoaccumulation index (I-Geo) for assessment of heavy metals pollution in Tigris River sediment in Baghded region. *J. Al-Nahrain Univ.*, **14**(4): 108-114.

Ross, S. M. (1994). "Sources and Forms of Potentially Toxic Metals in Soil Plant Systems." In Toxic Metals in Soil Plant System, edited by *S.M. Ross*,**3**_25. Chichester: John Wiley & Sons.

Sahu, C., Basti, S. and Sahu, S.K. (2021). Particulate Collection Potential of Trees as a Means to Improve the Air Quality in Urban Areas in India. *Environmental Processes*, pp.1- 19. https://doi.org/10.1007/s40710-021-00494-3.

Salman, S. A.; E. M. Abu El Ella and A. A. Elnazer (2018). Sequential extraction of some heavy metals is Southwest Giza soil, Egypt. *Egpt. J. Chem.*,**61**(5): 785-797.

Sarkar, S. K.; P. J. C.Favas; D. Rakshit and K. K. Satpathy (2014). Geochemical speciation and risk assessment of heavy metals in soils and sediments, In Hernandez-Soriano M.C. (Ed.): Environmental risk assessment of soil contamination. *InTech Publisher,* DOI: 10.5772/57295 (2014).

Shea, E.E. (1996). Lead Regulation Handbook. *Government Institutes Inc., Rockville,* MD, 240.

Shehata, Sh. M.; R. K. Badawy and Y. I. E. Aboulsoud (2019). Phytoremediation of some heavy metals in contaminated soil. *Bulletin of the National Research Centre* (2019) 43:189.

Singh, B. R. and E. Steinnes. (1994). "Soil and Water Contamination by Heavy Metals." *Soil Processes and Water Quality***15**: 233_272.

Singh, V. K.; K. P. Singh and D. Mohan (2005). Status of heavy metals in water and bed sediments of river Gomti-Atributary of Ganga River, India. *Environmental Monitoring and Assessment,***105**: 43-67.

Sinha, S.; K. Pandey.; A. K. Gupta and K. Bhatt (2005). Accumulation of metals in Vegetables and Crops grown in the area irrigated with river water. *Bul. Environ. Contam. Toxicol.***74**(1): 210-218.

Tangahu, B. V.; S. R. S. Abdullah, H. Basri, M. Idris, N. Anuar and M. Mukhlisin (2011). A Review on heavy metals (As, Pb, and Hg) uptake by plants through phytoremediation. *Inter. J. Chem. Eng.* doi:10.1155/2011/939161

The Editor-in-Chief of China Standards Press (1996). China Standard Compilation. *Standards Publishing Beijing, China,***209**: 359-361.

Tudi, M., Ruan, H.D., Wei, B., Wang, L., Tong, S., Kong, C. and Yang, L.S. (2021). Ecological and health risk assessment of trace elements in surface soil in an arid region of Xin Jiang, China. *Journal of Soils and Sediments,***21**(2), pp.936-947. https://doi.org/10.1007/s11368-020-02812- y.

Tume, P.; J. Bech.; L. Longan.; L. Tume.; F. Reverter.; J. Bech et al (2006). Baseline concentration of potentially toxic elements in natural surface soils in torrelles (Spain). *Environmental Forensics,***(7)**: 1-7.

Tuna, A. L.; M. Yildiztekin.; S. Koskeroglu.; I. Yokas and C. Kaya (2015). Maize (Zea mays L.) plant responses to excess copper, cadmium, cobalt, lead and chromium. *J.Fresenius*

Environmental Bulletin. By PSP Volume **24**-No 11b.

U.S. Government (2001). Control of emissions of hazardous air pollutants from mobile sources. *Final Rule. Fed Regis.***(66)**: 80-86.

Wang, J., Liu, W., Yang, R., Zhang, L. and Ma, J. (2013). Assessment of the potential ecological risk of heavy metals in reclaimed soils at an opencast coal mine. *Disaster Adv,***6**(S3), pp.366-377.

WHO (1995). Trace elements in human nutrition and health. *World Health Organization, Geneva,* Available at: http://www.who.int/nutrition/ publications/ micronutrients/9241561734/en/

WHO/FAO (1984). The role of food safety in health and development. *A Report of a Joint FAO/WHO Expert Committee on Food Safety.*

Willers, S.; L. Gerhardsson and T. Lundh (2005). Environmental tobacco smoke (ETS) exposure in children with Asthma-Relation between lead and cadmium, and cotinine concentrations in Urine. *Respir. Med.***99**(12): 1521-1527.

Winther, M.; and E. Slento (2010). Heavy metal emissions for danish road transport. *National Environmental Research Institute. Aarhus University.*

Wuana, R. A. and F. E. Okieimen (2011). Heavy metals in contamination soils: a review of sources, chemistry, risks and best available strategies for remediation. *Isrn Ecology* 2011. Doi: 10.5402/2011/402647.

Yan, X.; F. Zhang; C. Zeng; M. Zhang; L. P. Devkota and T. Yao (2012). Relationship between heavy metal concentration in soils and grasses of roadside farmland in Nepal. *Int. J. Environ. Res. Public Health***9** (9): 3209-3226.

Yang, M.; D. Zhang; L. Xu et al (2019). Heavy metals contents and risk assessment of farmland on the edge of Sichuan Basin. *J. Toxicol. Risk Assess.,***5**: 018.

Zeng, H (2008). Advance in the study on effects of traffic and transportation on soil and plants on both sides of the road. *J. Meteorol. Environ.***(24)**: 52-55.

Zheng, G. Z.; L. P. Yue; Z. P. Li and C. Chen (2006). Assessment on heavy metal pollution of agricultural soil in Guangzhong district. *Journal of Geographical Sciences,***16**(1), 105–113.

Zheng, X.; W. Zhao; X. Yan; T. Shu; Q. Xiong and F. Chen (2015). Pollution characteristics and health risk assessment of airborne heavy metals collected from Beijing busstations, Int. *J. Environ. Res. Public Health,* **12,** 9658–9671(2015).

Zurera, G.; B. Estrada; F. Rincou and R. Pozo (1987). Lead and Cadmium concentration levels in edible vegetables. *Bull. Environ. Cont. Toxicol.,***38**: 805-812.