BIOLOGIA (PAKISTAN)
June, 2018, 64 (1), 93-99

PKISSN 0006 – 3096 (Print)
ISSN 2313 – 206X (On-Line)

Assessment of Roadside Soil and Brassica Rapa Contamination by Heavy Metals in District Buner, Pakistan

MUJIBUR RAHMAN[1], MUHAMMAD AYAZ KHAN[1]*, WISAL SHAH[1] & ALIA NAZ[1]

[1]*Department of Environmental Sciences, University of Haripur, Pakistan*

ABSTRACT

This study was conducted in Buner district of Pakistan to investigate the presence of Cadmium (Cd) and Lead (Pb) in roadside soil and *Brassica rapa* (Shalgham). For that purpose, soil and *B. rapa* samples were collected from primary, secondary, tertiary roadside fields and control site. The samples were investigated for Cd and Pb presence via atomic absorption spectrometer (PerkinElmer, AAS-PEA-700). The Cd concentrations in soil ranged from 2.55 to 4.35 with mean value 3.31 mg/kg, 3 to 8.85 with mean value 5.41 mg/kg, 3.15 to 5.55 with mean value 4.9 mg/kg and 2.45 to 5.25 with mean value 3.93 mg/kg on primary, secondary, tertiary road and control site respectively. While the Pb concentration in soil was 0.85 to 40.85 with mean value 22.83 mg/kg, 13.25 to 35.3 with mean value 22.05 mg/kg, 29.83 to 43.42 with mean value 34.36 mg/kg and 1 to 36.1 with mean value 21.61 mg/kg on primary, secondary, tertiary road and control sites, respectively. In *B. rapa* the Cd concentrations ranged from 2.13 to 3.5 with mean value 2.87 mg/kg, 2 to 6 with mean value 3.6 mg/kg, 2 to 3.7 with mean value 2.8 mg/kg, 1.5 to 2.6 with mean value 2.21 mg/kg for primary, secondary, tertiary roads and control site respectively. While the Pb concentration in *B. rapa* ranged from 2.9 to 7.3 with mean value 5.12 mg/kg, 0.83 to 11 with mean value4.25 mg/kg, 0.33 to 5.3 with mean value 4.27 mg/kg, 0.2 to 11 with mean value 6.08 mg/kg for primary, secondary, tertiary roads and control site respectively. By applying Two-way ANOVA significant variation at $P \leq 0.05$ was found among the concentration of Cd and Pb in *B. rapa* and soil samples collected from various sample points. It was concluded that the *B. rapa* along different roads sides were found contaminated with Pb and Cd which may pose health risk.

Key words: Cadmium and lead toxicity, roadside soil, *Brassica rapa*, Buner

INTRODUCTION

Metal concentration beyond safe limit have potential toxicity and bring physiological changes in living beings. The main sources of heavy metals existed in the urban atmosphere due to pollutants from the traffic and transport, effluents from the industries and other man-made activities (Wiseman *et al., 2013*; Naszradi *et al.,* 2004). Air pollution is due to traffic flux, specially Cd and Pb together with particulate matter, oxides of nitrogen and sulfur etc. (Irvine *et al.,* 2009; Morton-Bermea, 2009).

It is a matter of fact traffic flux and concentrations of Pb have a strong association (Atiku *et al.,* 2011). The main cause of Pb pollution on pavement soils and vegetation is traffic discharges (Sharma *et al.,* 2008; Irvine *et al*., 2009; Abechi *et al*., 2010). Cadmium is commercially used in carburetors as alloy during combustion which tends to release into surroundings (Xu *et al.,* 2015; Liu *et al.,* 2007). The emitted heavy metals contaminate the soil, and from there they make their way to the vegetables.

Heavy metals like Cd and Pb are inoperable and harmful for vegetable' development; however, vegetation absorbs them swiftly when they exist in soil (Sanchez-Martin, 2000). The phytotoxic nature of Cd not only restrains the development of vegetables but perishes them too. Likewise, processes of respiration and photosynthesis are badly affected by Cd which also reduces the vegetables nutrient and water uptake. In addition, continuous load of heavy metal accumulation leads to soil degradation because due to Cd and Pb the plant root growth might be retarded (Irvine *et al.,* 2009; Cannata et al*.,* 2013). Due to decreased production of new cell pace, Cd reduces root growth, restrain anti-oxidative enzyme behavior of vegetables which

Author's Contribution: M.R., Wrote up article; **M.A.K**., Supervised research; **W.S**., Helped in review; **A.N**., Contributed in data analysis and graphs
*****Corresponding author: ayaz437@gmail.com

brings oxidative pressure in units (Liu *et al*., 2003).

The excessive intake of vegetables contaminated with heavy metals pose a risk to human health (Khan *et al*., 2009; Huang *et al*., 2014; Cai *et al*., 2015). In Toyoma Japan, a large number of people were affected by intake of Cd contaminated rice due to nearby mining activities which contaminated the source of irrigation water (Jamil, 2010). In addition, a number of studies have also been conducted in Pakistan to highlight contamination of soil and some food crops of potentially toxic heavy metals (Ullah *et al.,* 2017; Khan *et al.,* 2013; Khan *et al.,* 2011). However quite limited data is available on the contamination of roadside soil and vegetables. Keeping in view the toxicological impacts of the selected metals the current study has been designed to investigate Cd and Pb contamination of roadsides soil and *Brassica rapa* of District Buner, KP.

MATERIAL AND METHODS

Study Area

District Buner lies at 34°26’34.83’’ latitude and 72°29’57.58’’ longitude in the Khyber Pakhtunkhwa province of Pakistan. It is a land locked area surrounded by mountain ranges. Due to increasing population and business growth the number of vehicles in district is also increasing day by day (DHP, 2005). The existing road networks bifurcates into three categories i.e. primary roads that mainly carry mass traffic of the area, secondary roads extended from main road and tertiary roads extended from secondary roads also known as link roads. Agricultural fields exist on the banks of these roads were selected for the study.

Soil Sampling and Analysis

Randomly 10 soil samples were collected from each primary, secondary, tertiary road side fields with uniform distance of 4 meters from road sides and control site (field far away from road, having almost no traffic). A sample of 1 kg soil was drawn from 20 centimeters depth and put into an air tight polythene bags. The bags were transported to laboratory for analysis. Soil samples of 0.5 g were digested with concentrated HNO_3 and $HClO_4$ (5:1) ratio at 160°C till the appearance of crystal clear solution (Khan *et al.,* 2011). After digestion, the suspensions were filtered and were adjusted to 50 ml by adding deionized water. The concentrations of heavy metals i.e. Pb and Cd were determined by using atomic absorption spectrometer (Analyst 700 Perkin-Elmer) (Khan *et al*., 2013; Khan *et al.,* 2011).

Vegetable Sample Digestion and Analysis

The *B. rapa* samples were randomly collected from those points where soil samples were collected. An oven dried edible portion of sample of 0.5 g was put into acid washed digestion tube. A mixture of concentrated HNO_3, $HClO_4$ and H_2SO_4 (5:1:10) was added and left for 24 hrs. Next, the tubes were fixed in the digestion block at temperature of 80ºC for one hour and the temperature was increased from 120-130 ºC till complete digestion was done. After digestion, the suspensions were filtered and were adjusted to 50 ml by adding deionized water. The concentrations of heavy metals i.e. Pb and Cd were determined by using atomic absorption spectrometer (Analyst 700 Perkin-Elmer) (Khan *et al*., 2013).

Data Analysis

The collected data was analyzed for descriptive statistics i.e. mean, standard deviation etc. and Two-way ANOVA by using SPSS software.

RESULTS

Cd Concentration in Soil

The Cd concentration in soil ranged from 2.55 to 4.35 mg/ kg with <3.31> mean concentration on primary road site. On secondary road site, the concentration ranged from 3.0 to 8.85 mg/kg with <5.41> mean concentration. On tertiary road site, it ranged from 3.15 to 5.55 mg/kg with mean concentration <4.9>. On control site, the Cd concentration in soil ranged from 2.45 to 5.25 mg/kg with <3.93> mean concentration (Fig: 1).

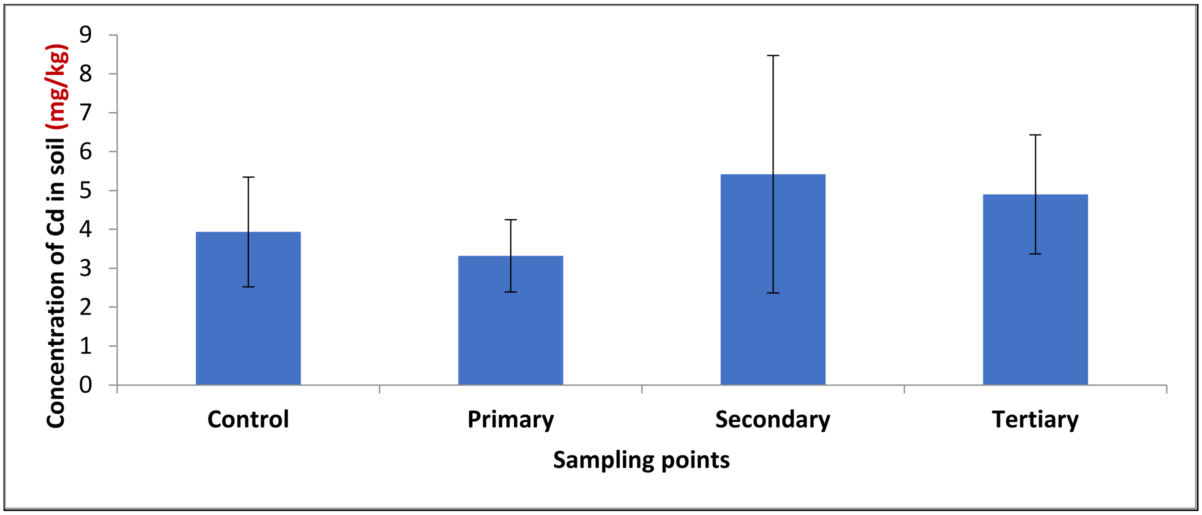

Fig: 1. Mean concentrations of Cd in soil of primary, secondary and tertiary roadside site: error bars indicate standard deviation.

Cd Concentration in *Brassica rapa*

The actual concentration of cadmium in *B. rapa* along with different sampling points namely primary, secondary, tertiary roadside fields and control site were determined. On primary road site, the Cd concentration in *B. rapa* ranged from 2.13 to 3.5 mg/kg with <2.87> mean concentration. On secondary road site, the Cd concentration in *B. rapa* ranged from 2.0 to 6.0 mg/kg with <3.6> mean concentration, on tertiary road site the Cd concentration in *B. rapa* ranged from 2.0 to 3.70 mg/kg with <2.80> mean concentration. On control site, the Cd concentration *B. rapa* ranged from 1.50 to 2.60 mg/kg with <2.21> mean concentration (Fig: 2).

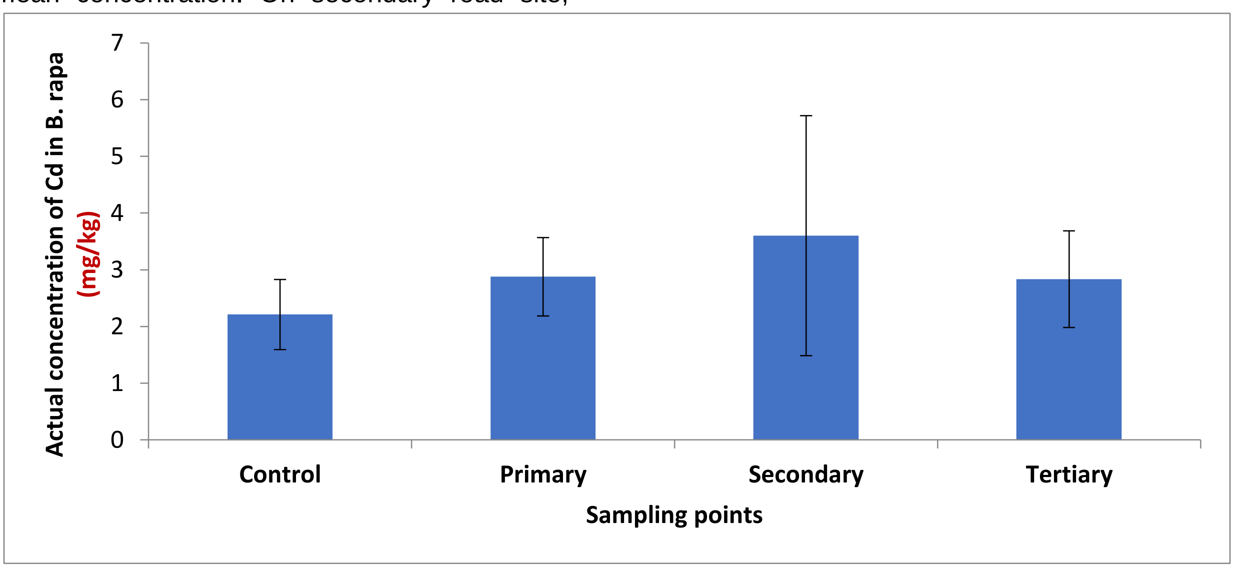

Fig: 2. Mean Cd concentrations in *B. rapa* grown along primary, secondary and tertiary roadside: error bars indicate standard deviation.

Pb Concentration in Soil

The concentration of Pb in soil along with different sampling points namely primary, secondary, tertiary roads and control site were determined. On primary road site, the Pb concentration in soil ranged from 0.85 to 40.85 mg/kg with <22.83> mean concentration. On secondary road site, the Pb concentration in soil ranged from 13.25 to 35.3 mg/kg with <22.05> mean concentration. On tertiary road site, the Pb concentration in soil ranged from 29.83 to 43.42 mg/kg with <34.36> mean concentration. On control site, the Pb concentration in soil ranged from 1.0 to 36.1 mg/kg with <21.61> mean concentration (Fig: 3).

Pb Concentration in *B. rapa*

The actual concentration of Pb Lead in *B. rapa* along with different sampling points namely primary, secondary, tertiary roads and control site were determined. On primary road site the Pb concentration *B. rapa* ranged from 2.90 to 7.3mg/kg with <5.12> mean concentration. On secondary road site, the Pb concentration *B. rapa* ranged from 0.83 to 11 mg/kg with <4.25> mean concentration. On tertiary road site, the Pb concentration *B. rapa* ranged from 0.33 to 5.3 mg/kg with <4.27> mean concentration. On control site, the Pb concentration *B. rapa* ranged from 0.2 to 11 mg/kg with <6.08> mean concentration (Fig: 4).

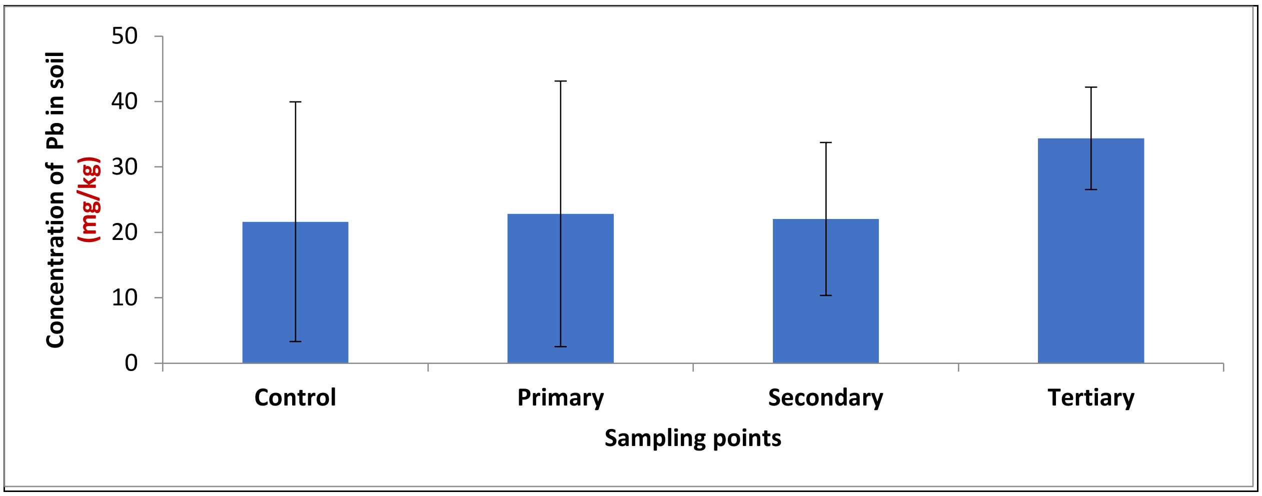

Fig: 3. Mean concentrations of Pb in soil of primary, secondary and tertiary roadside site: error bars indicate standard deviation.

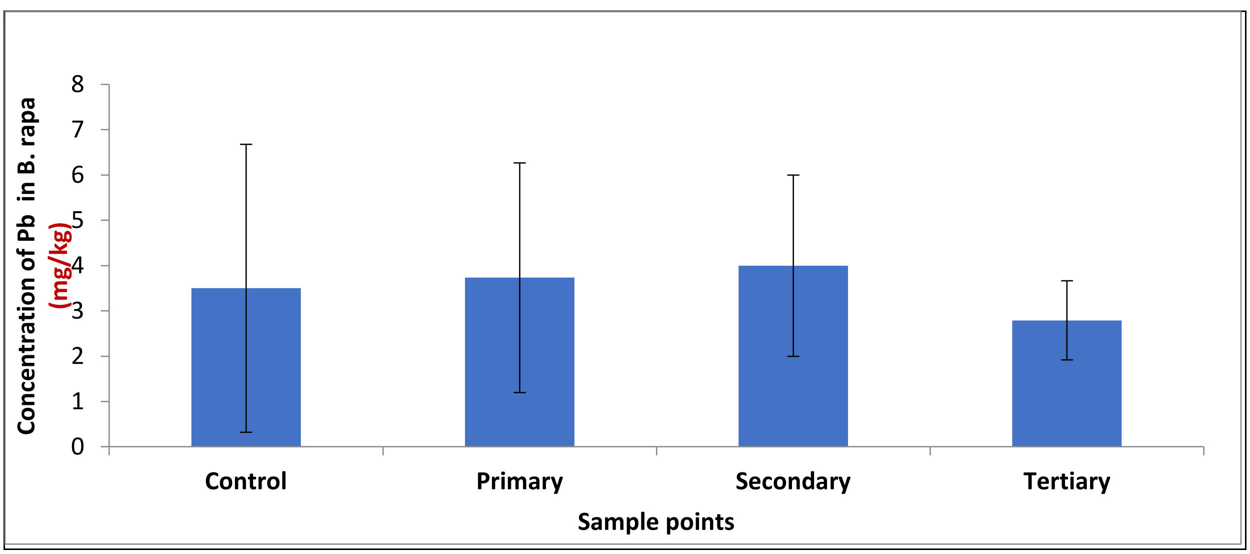

Fig: 4. Mean Pb concentrations in *B. rapa* grown along primary, secondary and tertiary roadside site: error barsindicate standard deviation.

DISCUSSION

Industrialization and motorization have greatly polluted the environment with several potential toxic heavy metals (Waisberg *et al.,* 2003). PM released in environment as a result of gasoline i.e. high-speed engine oil and high speed diesel burning have been analyzed for Cd and Pb contents. The concentration of Pb was found in the range of 0.0275-0.614 g/L while Cd was not detected. In high speed diesel mean value of Cd 0.003g/L and Pb 0.0038gm/L has been reported (Zhou *et al*., 2016).

Beside these a number of studies reported the contamination of roadside plants and soils with Pb and Cd (Rahim *et al.,* 2016; Bakirdere *et al.,* 2008; Fusconi *et al.,*2015; Botsou *et al.,* 2016). Important pathways for uptake of these toxic heavy metals are particulate matters and food (Sandalio *et al.,*2001). Vegetables uptake and accumulate high amount of heavy metals than other food crops (Cenkci *et al.*, 2010). Daily intake of heavy metals like Cd and Pb pose health risk to the general population (Zhou *et al*., 2016). The presence of Pb and Cd in the vegetable and soil samples is a health risk (Shaheen *et al.,*2016; Khan *et al.,*2009; Huang *et al.,*2014; Cai *et al.,*2015; Sharma, *et al.,* 2016) for the residents of the study area. Because both Pb and Cd are known for their toxicities. Exposure to which can cause a number of fatal diseases. They include renal malfunction and neurological issues. Studied so far highlighted the harmful impacts of these metals up to some extent while the rest are still awaited to be explored (Meeker et al., 2008).

CONCLUSION

The study estimated the concentration of potentially toxic heavy metals absorbed by roadside soil and vegetables. Comparison of the data of Cd and Pb in soils and *B. rapa* of primary, secondary, tertiary and control sites showed significant variations. So, the higher concentration of these heavy metals may be due to high rate of vehicular emissions, whereas the concentration of Cd and Pb in control site might be due to geographical factors rather than traffic. It was concluded that the *B. rapa* along different roads sides were found contaminated with Pb and Cd which may pose health risk.

REFERENCES

Abechi, E. S., Okunola, O. J., Zubairu, S. M. J., Usman, A. A. & Apene, E., 2010. Evaluation of heavy metals in roadside soils of major streets in Jos metropolis, Nigeria. *Journal of Environmental Chemistry and Ecotoxicology*, ***2*(6):** 98-102.

Atiku, F. A., Ikeh, P. O., Faruk, U. Z., Itodo, A. U., Abdulhamid, A. & Rikoto, I.I., 2011. Comparative test analysis of petroleum (diesel and gasoline) soots as potential sources of toxic metals from exhausts of power plants. *Archives of Applied Science Research*, ***3*(4)**:147-156.

Bakirdere, S. & Yaman, M., 2008. "Determination of lead, cadmium and copper in roadside soil and plants in Elazig, Turkey". *Environ. Monit. Assess.* **136**: 401– 410.

Botsou, F., Sungur, A., Kelepertzis, E. & Soylak, M., 2016. Insights into the chemical partitioning of trace metals in roadside and off-road agricultural soils along two major highways in Attica's region, Greece. *Ecotoxicology and Environmental Safety*, **132**:101-110.

Cai, L. M., Xu, Z. C., Qi, J. Y., Feng, Z. Z. & Xiang, T.S., 2015. Assessment of exposure to heavy metals and health risks among residents near Tonglushan mine in Hubei, China. *Chemosphere*, **127**:127-135.

Cannata, M. G., Bertoli, A. C., Carvalho, R., Bastos, A. R. B., Freitas, M. P., Augusto, M. S. & Varennes, A. D., 2013. Toxic metal in Raphanus sativus: assessing the levels of cadmium and lead in plants and damage to production. *Revista de Ciências Agrárias*, **36(4)**: 426-434.

Cenkci, S., Ciğerci, İ. H., Yıldız, M., Özay, C., Bozdağ, A. & Terzi, H., 2010. Lead contamination reduces chlorophyll biosynthesis and genomic template stability in Brassica rapa L. *Environmental and experimental botany*, **67(3)**: 467-473.

District health profile Buner, 2005. Pakistan initiative for mother and new borns. Paiman organization.

Fusconi, A., Repetto, O., Bona, E., Massa, N., Gallo, C., Dumas-Gaudot, E. & Berta, G., 2006. Effects of cadmium on meristem activity and nucleus ploidy in roots of Pisum sativum L. cv. Frisson seedlings. *Environmental and Experimental Botany*, **58(1)**: 253-260.

Huang, Z., Pan, X. D., Wu, P. G., Han, J. L. & Chen, Q., 2014. Heavy metals in vegetables and the health risk to population in Zhejiang, China. *Food Control*, ***36*** **(1)**:248-252.

Irvine, K. N., Perrelli, M. F., Ngoen-klan, R. & Droppo I. G., 2009. “Metal levels in street sediment from an industrial city: spatial trends, chemical fractionation, and management implications”. *J. Soils Sediments*. 9:1.

Khan, S., Farooq, R., Shahbaz, S., Khan, M. A. & Sadique, M., 2009. Health risk assessment of heavy metals for population via consumption of vegetables. *World Appl Sci J*, **6(12)**: 1602-1606.

Khan, S., Khan, M. A. & Rehman, S. 2011. Lead and cadmium contamination of different roadside soils and plants in Peshawar City, Pakistan. *Pedosphere.* **21(3)**:351–357.

Khan, S., Naz, A., Asim, M., Ahmad, S. A., Yousaf, S. & Muhammad, S., 2013. Toxicity and bioaccumulation of heavy metals in spinach seedlings grown on freshly contaminated soil. *Pakistan Journal of Botany*, *45* (supplement 1): 501-508.

Liu, D., Jiang, W. & Gao, X., 2003. Effects of cadmium on root growth, cell division and nucleoli in root tip cells of garlic. *Biologia plantarum*, ***47*****(1)**:79-83.

Liu, Y. J., Zhu, Y. G. & Ding, H., 2007. Lead and cadmium in leaves of deciduous trees in Beijing, China: Development of a metal accumulation index (MAI). *Environmental Pollution*, **145(2)**: 387-390.

Meeker, J. D., Rossano, M. G., Protas, B., Diamond, M. P., Puscheck, E., Daly, D., Paneth, N. & Wirth, J.J., 2008. Cadmium, lead, and other metals in relation to semen quality: human evidence for molybdenum as a male reproductive toxicant. *Environmental health perspectives*, **116(11)**:1473.

Morton-Bermea, O., Hernández-Álvarez, E., González-Hernández, G., Romero, F., Lozano, R. & Beramendi-Orosco, L. E., 2009. Assessment of heavy metal pollution in urban topsoils from the metropolitan area of Mexico City. *Journal of Geochemical Exploration*, **101(3)**: 218-224.

Naszradi, T., Badacsonyi, A., N´emeth, N., Tuba, Z. & Bati, F., 2004. “Zinc, lead and cadmium content in meadow plants and mosses along the M3 Motorway (Hungary)”. *J. Atmos. Chem.* **49**: 593–603.

Sanchez-Martin, M. J., Sanchez-Camazano, M. & Lorenzo, L.F., 2000. Cadmium and lead contents in suburban and urban soils from two medium-sized cities of Spain: Influence of traffic intensity. *Bulletin of Environmental Contamination and Toxicology*, **64(2)**: 250-257.

Sharma, N., Irfan, N. M., Khan, I. N., Islam, S., Islam, M. S. & Ahmed, M. K., 2016. Presence of heavy metals in fruits and vegetables: Health risk implications in Bangladesh. *Chemosphere*, **152**: 431-438.

Sharma, R. K., Agrawal, M. & Marshall, F. M., 2008. Heavy metal (Cu, Zn, Cd and Pb) contamination of vegetables in urban India: A case study in Varanasi. *Environmental Pollution* **154(2)**: 254-263.

Ullah, Z., Naz, A., Saddique, U., Khan, A., Shah, W. & Muhammad, S., 2017. Potentially toxic elements concentrations and human health risk assessment of food crops in Bajaur Agency, Pakistan. *Environmental Earth Sciences*, ***76*****(14)**: 482.

Waisberg, M., Joseph, P., Hale, B. & Beyersmann, D., 2003. Molecular and cellular mechanisms of cadmium carcinogenesis. *Toxicology*, **192(2)**:95-117.

Wiseman, C. L., Zereini, F. & Püttmann, W., 2013. Traffic-related trace element fate and uptake by plants cultivated in roadside soils in Toronto, Canada. *Science of the Total Environment*, **442**:86-95.

Xu, L., Wang, Y., Liu, W., Wang, J., Zhu, X., Zhang, K., Yu, R., Wang, R., Xie, Y., Zhang, W. & Gong, Y., 2015. De novo sequencing of root transcriptome reveals complex cadmium-responsive regulatory net-works in radish (Raphanus sativus L.). *Plant Science*, **236**:313-323.

Zhou, H., Yang, W. T., Zhou, X., Liu, L., Gu, J. F., Wang, W. L., Zou, J. L., Tian, T., Peng, P.Q. & Liao, B.H., 2016. Accumulation of Heavy Metals in Vegetable Species Planted in Contaminated Soils and the Health Risk Assessment. *International journal of environmental research and public health*, **13(3)**:289.