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Assessment of heavy metals pollution in soil and date palm (*Phoenix dactylifera* L.) leaves sampled from Basra/Iraq governorate

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Abstract. The leaves and soil of date palm (*Phoenix dactylifera* L.) were assessed for their pollution by different heavy metals (HMs) including Cd, Co, Cr, Ni and Pb. Three different areas at Basra governorate have been selected to be as rural (Shaat Al-Arab area - SAR), industrial (Najibiy Power Station area - NPS) and Al-Zubair high way area - ZHW. The concentrations of HMs were analysed in both soil and leaves by using Atomic Absorption. Results showed that the highest levels of pollution were observed at ZHW, both in soil and leaves samples; which were 58.20 and 19.50 mg kg^{-1}, respectively, followed by NPS and reported the means of 51.30 and 11.90 mg kg^{-1}, respectively. The lowest averages of pollution by HMs were seen at SAR area. It was found that the Pb concentrations were the highest among examined HMs and recorded the values of 115.0 and 40.40 mg kg^{-1}, in soil and leaves of date palm, respectively, followed by Cr, while the lowest averages of pollution were observed with Cd in both soil and date palm leaves samples. The dominant of HMs found in the order of Pb> Cr> Ni> Co> Cd, in soil and date palm leaves. The highest levels of Pb, Cd and Ni were found to be exceeded the permissible levels of EU standards in the soils of ZHW and NPS, thus, required an urgent interaction to reduce these risky levels by suitable soil remediation procedures.
Key Words: heavy metals, soil and plant pollution, biomonitor, date palm.

Introduction. Pollution of soil, dust, water and foods by highly toxic heavy metals represents a great environmental concern, and continuous to receive particular attention around the world (Al-Kashman 2004; Al-Khashman & Shawabkeh 2006; Al-Khashman et al 2011; Williams & Pillay 2011; Serbula et al 2012). This attention is attributed to their adverse effects on the health of human being, animals and plants. Heavy metals have an adverse effect on human physiology (Bailey et al 1999; Kobya et al 2005; Zhao et al 2010; Sapkota & Cioppa 2012; Shaikh et al 2013); many researches showed heavy metals' affinity for other elements such as sulphur disrupting enzyme functions in living cells (Bailey et al 1999; Manahan 2004; Kobya et al 2005). Cd, Pb and Hg ions have the ability to bind to cell membrane, interfering with the cell transport process (Capuana et al 2011; Aldoobie & Beltagi 2013). Heavy metals are non-biodegradable and tend to accumulate in the tissues of living organisms (Baird & Cann 2005; Viehweger 2014).

Elevated levels of heavy metals pollution worldwide is due to the anthropogenic activities such as mining, smelting, energy, electroplating, fuel production, power emission, intensive agriculture, waste water irrigation, sludge, dumping and dust (Yadav et al 2010; Williams & Pillay 2011; Muhammad et al 2011). It's noteworthy, that the heavy metals are considered as natural elements of the Earth crust, and they have high densities (5 g cm^{-3}) (Baird & Cann 2005; Bhargava et al 2012), and not all of the heavy metals are toxic to the plant within the acceptable concentrations such as iron (Fe) and zinc (Zn), and are biologically important and essential for their growth and production (Alloway 1990).

It is important here to introduce some definitions, in the plant; the heavy metals could be defined as "Heavy metals are metallic chemical elements that have high density and are toxic even at low concentrations" (Bhargava et al 2012), also, the phytotoxicity defined as "The ability of substances or elements to disrupt the normal function of a plant" (Jones & Benton 1998). The typical phytotoxicity symptom of heavy metals on different plants is chlorosis; "which is a light green to yellow colouration of the leaves or whole plant" (Jones & Benton 1998).

The evaluation and monitoring of heavy metals levels in soil, air, dust, water and food are so important, and the biomonitor plants as biological indicators have been employed to detect and determine the deposition, accumulation and distribution of heavy metals pollution (Cicek & Koparal 2004; Rossini Oliva & Mingorance 2006; Al-Khashman et al 2011). Thus, the leaves of higher plants have been used for biomonitoring heavy metals, including *Nerium oleander, Robinia pseudoacacia, Olea europaea, Populus* spp., *Pinus* spp. and *Phoenix dactylifera* (Aksoy & Ozturk 1997; Serbula et al 2010; Madejon et al 2006; Rossinin Oliva & Mingorance 2006; Al-Khashman et al 2011). The assessment of air heavy metals pollution using different parts of plants are reliable methods to relate the air quality on large areas closer to industrial complexes, and a useful tool to monitor the long-term pollution and easy sampling without using expensive procedures (Serbula et al 2012).

The date palm (*Phoenix dactylifera* L.) is a dioeciously monocotyledon of the family Arecaceae, with a considerable importance, in terms of agricultural, cultural, socioeconomic and scientific in different parts around the world, more specifically, in Middle East regions (Abass 2013). The date palm tree can be growing in different areas, and can survive within a wide range of temperatures and grows almost in all type of soils. Most importantly, it can grow over large areas by roadsides in industrial, rural, residential and agricultural areas even when high level of pollution exists (Al-Khashman et al 2011).

The aims of the current study were to determine the level of airborne and soil heavy metals pollution, and to detect the possibility of using date palm leaves as biomonitor for these heavy metals pollution in different areas of Basra governorate.

Material and Method

Description of sampling areas. Basra is a governorate in the republic of Iraq and located in the southern part of Iraq, bordering Kuwait to the south and Iran to the east (Latitude: 30.36° N; Longitude: 47.36° E). It has an estimated population of 3.5 millions in 2011 (Abass 2013). Three different areas were selected to investigate their heavy metals content in Basra governorate which were as follow: 1 - Shaat Al-Arab district (SAR); 2 - Najibiya Power Station (NPS); 3 - Al-Zubair Highway (ZHW).

Sampling collection and preparation. The sampling was carried out during the summer of 2012. The samples of soil and date palm leaves were collected from examined areas at July of 2012 to avoid rain washing of heavy metals.

Soil sampling and preparation. The soil samples were collected from upper A-horizon from each three chosen areas. Soil samples were air dried, homogenized and sieved through 2 mm plastic sieve. Storage of samples was done in polyethylene bags at room temperature. Physical properties including the pH and Electrical Conductivity (EC; dS m^{-1}) were measured in mixture of soil and double-distilled water with ratio of 1:25 (w/v) according to Das & Maiti (2008). For heavy metal analysis, soil samples were ground in mill into finer than 200 mesh size. Soil sample of 0.5 g was oven dried then digested in Teflon beaker with the mixture of hydoflouric acid and hydrochloric acid (40:10 mL) at 140^{o}C. Subsequently, 1:1 HCl was added and the solution was diluted to 100 mL by double distilled water (Rashed 2010).

Date palm leaves sampling and preparation. The leaf samples were collected only from young date palm tree with a maximum of 5 m trunk height; four leaflets per date palm from the median position along the rachis were picked and united (Al-Shayeb et al 1995). About 200 g (fresh weight) of date palm leaves were collected from each site, and dried at an oven (105^{o}C) for 4 hours to constant weight. Subsequently, homogenization with a laboratory mill was performed. Each site samples were stored in clean, self-sealing plastic bags. Approximately 2 g of each sample was transferred into cleaned vitreosil crucible and pre-ashed on a hot plate until all of the fumes disappeared, then transferred into muffle furnace and ashed at 480^{o}C (Odukoya et al 2000).

Heavy metals analysis. The concentrations of Cadmium (Cd), Chromium (Cr), Cobalt (Cb), Nickel (Ni) and lead (Pb) were analyzed using Flame Atomic Absorption Spectrophotometer (Perkin Elmer AAS Analysis 300, USA) connected with deuterium background correction, hollow cathode lamps and acetylene burner. Standard solutions for each heavy metal were prepared and used for calibrations according to Al-Qutob et al (2013). Three reference materials were used to determine the accuracy (Al-Khashman et al 2011).

Data analysis. Results of chemical analysis such as range, means and standard deviation were anaylsed by Excell 2007 (MS). All of ANOVA results were analysed using SPSS version 13.0 (IL, USA). Differences were considered significant when $p < 0.05$. Turkeys test was applied when ANOVA revealed significant differences.

Results and Discussion

The soil characteristics. Results of Table 1 showed that the pH values of soil samples were ranged in a narrow interval and found to be within 6.4-7.4, which suggests neutral to low acidic conditions. The analysis of soil electrical conductivity showed that the soil of ZHW was the highest among other areas at the level of 84 dS m^{-1}, compared with the lowest level 6.0 dS m^{-1} which observed at the soil of SAR.

Table 1

Soil chemical properties

Area	*Soil characteristics*	
	pH	*EC (dS m^{-1})*
SAR	6.4±0.2*	6.0±1.1
NPS	7.4±0.4	47.0±3.3
ZHW	7.3±0.2	84.0±5.1

* Mean follows by standard deviation.

The levels of heavy metals in the soil. Table 2 summarizes the concentrations of heavy metals in soil samples collected from different areas at Basra governorate; the concentrations of heavy metals (Cd, Co, Cr, Ni and Pb) vary greatly according to the examined areas.

Pb values were found to be higher at all examined areas compared with other heavy metals values; the highest level was observed at the soil of ZHW and recorded a value of 187 mg kg^{-1}, while the lowest level was seen at the soil of SAR which was 65 mg kg^{-1}. The main average of Pb at all examined soils was 115 mg kg^{-1} and significantly higher than all other heavy metals.

For the values of Cr and Ni, the soil of NPS were found to be higher and reached 83.6 and 71.9 mg kg^{-1}, respectively, compared with the lowest average which were 34.5 and 0.25 mg kg^{-1}, in the soil of ZHW and SAR, respectively. The high levels of Cd and Co were observed in the soils of NPS and ZHW, respectively.

Based on the results of Table 2, the soil heavy metal concentrations were found in the order of: Pb > Cr > Ni > Co > Cd which were 115, 60.9, 36.9, 10.25 and 2.8 mg kg^{-1}, respectively, whereas the level of pollution at the studied areas has followed the order of: ZHW > NPS > SAR which reported the values of: 58.20, 51.30 and 26 mg kg^{-1}, respectively.

Table 2

Heavy metals concentrations (mg kg^{-1}) in soil samples at different areas of Basra governorate

Heavy metals	Areas			HMs average
	SAR	NPS	ZHW	
Cd	0.22±0.05*	4.40±0.09	3.80±0.1	2.80e**
Co	0.25±0.05	3.50±0.08	27.00±1.5	10.25d
Cr	64.60±3.1	83.60±3.5	34.50±1.5	60.90b
Ni	0.25±0.05	71.90±3.3	38.60±1.5	36.90c
Pb	65.00±3.1	93.50±4.5	187.00±10.1	115.00a
Area average	26.00c	51.30b	58.20a	

* Mean follows by standard deviation; ** Means within each column followed by the same letter are not significantly different at p < 00.5 levels determined by Turkeys test.

According to the results of HMs analysis, the level of pollution was observed to be low at the area of SAR at Basra governorate, while was highest levels were observed at the area of ZHW. The low levels of HMs pollution at SAR which considered as a rural area are in a good agreement with the results of Al-Khashman et al (2011), which showed that the lowest level of HMs pollution was seen at the rural area for the Pb, Cu, Zn, Ni, Cr and Fe, compared to the highest levels of pollution at the areas of urban, suburban and industrial for the same HMs in Jordan. The high levels of HMs pollution at ZHW could be attributed to the aerial deposition alongside the roads which positively correlated with the traffic density, as well as the distance from the roadside (Aksoy & Ozturk 1997; Al-Khashman et al (2011). These results are in a good accordance with the results of Al-Khashman et al (2011) when they studied the level of HMs pollution at different areas in Jordan, and highlighted that the highest concentrations of different HMs in date palm leaves and soil alongside the roadside.

The NPS is considered as an industrial area, so the HMs deposition in both soil and date palm leaves samples (Table 3) could be attributed to power industry in which the process and production of power require a substantial amount of energy supplied by fossil fuels burning, as well as traffic activities in the station (Carreras & Pignata 2002; Banat et al 2005; Al-Khashman et al 2011). Generally, the heavy metal pollution of soil could be attributed to the anthropogenic activities which play a pivotal role in dispersal of HMs into the atmosphere, and subsequently deposition into soils (Bin Chen et al 2005; Al-Khashman et al 2011; Schreck et al 2012).

In our study, HMs analysis elucidated that the soil of ZHW was the most polluted soil, followed by industrial area of NPS, which both could be explained by the fact that these soils receive heavy metals from atmospheric pollution, as it considered as the major contributor of soil HMs (Pandey & Pandey 2009; Sapkota & Cioppa 2012).

In terms of specific heavy metal pollution, the results showed that Pb was the most frequent heavy metal in soil and date palm leaves samples (115.0 and 40.40 mg kg^{-1}, respectively (Tables 2 and 3) in the area of ZHW. This result could be attributed to the traffic activity and fossil fuel burning (Al-Khashman & Shawabkeh 2006; Al-Khashman et al 2011), while the agricultural area of SAR showed the lowest level of pollution by Pb which thought to be from chemical fertilizers, manures and pesticides (Biasioli et al 2005). Cr was found to be the second most dominant heavy metal in all soil and date palm leaves samples; the highest concentrations of Cr were found in the area of NPS, which is well known as a common pollutant in industrial areas among other HMs (Al-Khashman & Shawabkeh 2006). It is noteworthy that the Ni concentrations were found to be high in both soil and date palm leaves samples of NPS and ZHW areas, thus could be explained by anthropogenic activities, trafficking activity, as well as the corrosion of cars (Ferguson & Kim 1991; Al-Khashman 2004). The Cd levels were found to be the lowest among other HMs in the soil and date palm leaves samples, the source of Cd in plant parts is mostly absorbed from phosphate fertilizers, which usually contains a contaminant Cd (Baird 1999; Ward 2000).

The levels of heavy metals in the plant materials. The mean average of heavy metal concentrations in the leaves of date palm at different areas of Basra governorate are presented in Table 3. Pb levels were observed to be higher in all studied areas in comparison with other heavy metals; the Pb concentrations were 75.5, 25.25 and 20.50 mg kg^{-1}, in the date palm leaves samples of ZHW, NPS and SAR, respectively.

Both Co and Ni were undetectable in the date palm leaves samples of SAR area. It is noted from the data of Table 3, that the level of pollution of all examined heavy metals (with an exception of Cr) were found to be the less in the date palm leaves samples of SAR, while, the values of Cd, Cr and Ni were observed with the highest levels in the date palm leaves samples of NPS and reported the concentrations of 1.3, 17.25 and 15.5 mg kg^{-1}, respectively.

The orders of heavy metals, as well as the pollution level of studied areas were the same as observed in the soil patterns. The concentrations of heavy metal in date palm leaves were found in the order of: Pb > Cr > Ni > Co > Cd which were 40.4, 9.40, 8.7, 2.25 and 0.75 mg kg^{-1} respectively, whereas, the level of pollution at the studied areas was followed the order of: ZHW > NPS > SAR which reported the values of 19.5, 11.9 and 5.4 mg kg^{-1}, respectively.

Table 3

Heavy metals concentrations (mg kg^{-1}) in date palm leave samples at different areas of Basra governorate

Heavy metals	*Areas*			*HMs average*
	SAR	*NPS*	*ZHW*	
Cd	0.10±0.05*	1.30±0.08	0.85±0.05	0.75 d**
Co	Ud***	0.25±0.05	6.50±0.07	2.25c
Cr	6.50±1.1	17.25±1.5	4.50±0.05	9.40b
Ni	Ud	15.50±1.1	10.50±0.9	8.70b
Pb	20.50±1.5	25.25±2.1	75.50±4.1	40.40a
Area average	5.40c	11.90b	19.50a	

* Mean follows by standard deviation; **Means within each column followed by the same letter are not significantly different at p < 00.5 levels determined by Turkeys test; *** Undetectable.

The results of HMs pollution in date palm leaves samples revealed the possibility of using these plant parts as a biomonitor for HMs pollution. The suitability of date palm leaves for monitoring and assessment of HMs pollution have been proved by several studies including Al-Khlaifat & Al-Khashman (2007) and Al-Khashman et al (2011), and this conclusion could be supported by the fact that date palm trees can grow at different areas, and survive within a wide range of temperatures and soils, but most importantly, it can grow over large areas by roadsides in industrial, rural, residential and agricultural areas (Al-Khashman et al 2011). The presented results proved the suitability of date palm leaves in all examined areas to be used as a biomonitor for airborne heavy metal pollution.

The permissible limits of heavy metals in soil. Regarding the permissible limits of heavy metals in soil and according to European Union's Standards (2006), both Cd and Pb have exceeded the limits at ZHW area; their averages were 3.8 and 187 mg kg^{-1}, respectively, compared to EU standards which were 3 and 100 mg kg^{-1}, respectively (Table 4). Hence, the level of Ni was found to be exceeded the limit at NPS and reported the value of 71.90 mg kg^{-1}, compared to EU limit (50 mg kg^{-1}). Thereby, more attention should be paid to these toxic levels (Cd, Ni and Pb) in examined areas to apply any suitable remediation for soil treatment from these contaminants.

Table 4

The permissible limits of certain heavy metals (mg kg^{-1}) in agricultural soil according to EU (2006)

Heavy metals	*Acceptable level*
Cd	3
Co	50
Cr	100
Ni	50
Pb	100

Conclusions. The results of current study demonstrate that the levels of heavy metal pollution in different areas at Basra governorate have been varied according to the nature of examined area. The highest levels of pollution were observed at the area of Al-Zubair highway, whereas, the lower level of pollutions were examined at the area of Shaat-Al-Arab. The mean values of analysed heavy metals were found in the order of: Pb > Cr > Ni > Co > Cd in both soil and date palm leaves samples. Hence, the order of pollution of examined areas was the following: ZHW > NPS > SAR. The highest metal concentrations of Pb and Cd were found to be exceeded the permissible level set by European Union standards in the soil of Al-Zubair highway, whereas, the Ni level at Najibia power station has exceeded the permissible level. These findings suggest that more attention should be paid for soil remediation at the examined areas to decrease these risky levels such as phytoremediation using high potential plant heavy metal accumulators as a soil treatment. The demonstrated results show that the leaves of date palm can be used as a biomonitor of heavy metal pollution at the examined areas.

In the future work, further studies are required to assess the level of heavy metal pollution in different areas in Basra governorate with more intensive sampling to cover the whole governorate and getting the whole picture.

References

Abass M. H., 2013 Microbial contaminants of date palm (*Phoenix dactylifera* L.) in Iraqi tissue culture laboratories. Emirates Journal of Food and Agriculture 25(11):875-882.

Aksoy A., Ozturk M. A., 1997 *Nerium oleander* L. as a biomonitor of lead and other heavy metal pollution in Mediterranean environments. Science of the Total Environment 205:145-150.

Aldoobie N. F., Beltagi M. S., 2013 Physiological, biochemical and molecular responses of common bean (*Phaseolus vulgaris* L.) plants to heavy metal stress. African Journal of Biotechnology 12(29):4614-4622.

Al-Khashman O. A., 2004 Heavy metals distribution in dust, street dust and soil from the work place in Karak Industrial Estate, Jordan. Atmospheric Environment 38:6803-6812.

Al-Khashman O. A., Shawabkeh R., 2006 Metal distribution in soil around the cement factory in southern Jordan. Environmental Pollution 140:387-394.

Al-Khashman O. A., Al-Muhtaseb A. H., Ibrahim K. A., 2011 Date palm (*Phoenix dactylifera* L.) leaves as biomonitors of atmospheric metal pollution in arid and semi-arid environments. Environmental Pollution 159:1635-1640.

Al-Khlaifat A. L., Al-Khashman O. A., 2007 Atmospheric heavy metal pollution in Aqaba city, Jordan, using *Phoenix dactylifera* leaves. Atmospheric Environment 41:8891-8897.

Alloway B. J., 1990 Heavy metals in soils. Glasgow and London: Blackie and Son Ltd., 339 pp.

Al-Shayeb S. M., Al-Rajhi M. A., Seawrd M. R. D., 1995 The date palm (*Phoenix dactylifera* L.) as a biomonitor of lead and other elements in arid environments. Science of the Total Environment 168:1-10.

Al-Qutob M., Alatrash H. M., Abol-Ola S., 2013 Determination of different heavy metals concentrations in cosmetics purchased from the Palestinian markets by ICP/MS. AES Bioflux 5(3):287-293.

Bailey S. E., Olin T. J., Bricka R. M., Adrian D. D., 1999 A review of potentially low-costs sorbents for heavy metals. Water Research 33:2469-2479.

Baird C., 1999 Environmental chemistry. W. H. Freeman & Company, New York, 650 pp.

Baird C., Cann M., 2005 Environmental chemistry, 3rd edit. W. H. Freeman and Company, New York, 752 pp.

Banat K. M., Howari F. M., Al-Hamad A. A., 2005 Heavy metals in urban soils of central Jordan: should we worry about their environmental risks. Environmental Research 97:258-273.

Bhargava A., Carmona F. F., Bhargava M., Srivastava S., 2012 Approaches for enhanced phytoextraction of heavy metals. Journal of Environmental Management 105:103-120.

Biasioli R., Barberis R., Ajmone-Marsan F., 2005 The influence of a large city on some soil properties and metal content. Science of the Total Environment 356:154-164.

Bin Chen T., Ming Zheng Y., Lei M., Chun Huang Z., Tao Wu H., Chen H., Ke Fan K., Yu K., Wu X., Zheng Tian Q., 2005 Assessment of heavy metal pollution in surface soils of urban parks in Beijing, China. Chemosphere 60:542-551.

Capuana M., 2011 Heavy metals and woody plants-biotechnologies for phytoremediation. iForest – Biogeosciences and Forestry 4:7-15.

Carreras H. A., Pignata M. L., 2002 Biomonitoring of heavy metals and air quality in Cordoba city, Argentina, using transplanted lichens. Environmental Pollution 17:77-87.

Cicek A., Koparal A. S., 2004 Accumulation of sulfur and heavy metals in soil and tree leaves sampled from surroundings of Tuncbilek thermal power plant. Chemosphere 57:1031-1036.

Das M., Maiti S. K., 2008 Comparison between availability of heavy metals in dry and wetland tailing of an abandoned copper tailing pond. Environmental Monitoring and Assessment 137:343-350.

European Union, 2006 Commission regulator (EC) No. 1881/2006 of 19th December 2006, setting maximum levels of certain contaminants in foodstuffs. Off. J. Eur. Union L., 364, pp. 4-24.

Ferguson J. E., Kim N. D., 1991 Trace elements in street and house dusts: source and speciation. Science of the Total Environment 100:125-150.

Jones J., Benton J., 1998 Plant nutrition manual. CRC Press, Boca Raton, FL.

Kobya M., Demirbas E., Senturk E., Ince M., 2005 Adsorption of heavy metal ions from aqueous solutions by activated carbon from apricot stone. Bioresource Technology 96:1518-1521.

Madejon P., Maranon T., Murillo J. M., 2006 Biomonitoring of trace elements in leaves and fruits of wild olive and holm oak trees. Science of the Total Environment 355:187-203.

Manahan S. E., 2004 Environmental chemistry, 8th edition. Boca Raton: CRC Press LLC, 816 pp.

Muhammad S., Tahir Shah M., Khan S., 2011 Heavy metal concentrations in soil and wild plants growing around Pb-Zn sulfide terrain in the Kohistan region, northern Pakistan. Microchemical Journal 99:67-75.

Odukoya O. O., Arowolo T. A., Bamgbose O., 2000 Pb, Zn and Cu levels in tree barks as indicator of atmospheric pollution. Environment International 26:11-16.

Pandey J., Pandey U., 2009 Accumumation of heavy metals in dietary vegetables and cultivated soil horizon in organic farming system in relation to atmospheric deposition in a seasonally dry tropical region of India. Environmental Monitoring and Assessment 148:61-74.

Rashed M. N., 2010 Monitoring of contaminated toxic and heavy metals from mine tailing through age accumulation in soil and some wild plants at southeast Egypt. Journal of Hazardous Materials 178:739-746.

Rossini Oliva S., Mingorance M. D., 2006 Assessment of airborne heavy metal pollution by aboveground plant parts. Chemosphere 65:177-182.
Sapkota B., Cioppa M. T., 2012 Using magnetic and chemical measurements to detect atmospherically-derived metal pollution in artificial soils and metal uptake in plants. Environmental Pollution 170:131-144.
Schreck E., Foucault Y., Sarret G., Sobanska S., Cecillon L., Castrec-Rouelle M., Uzu G., Dumat C., 2012 Metal and metalloid foliar uptake by various plant species exposed to atmospheric industrial fallout: mechanisms involved for lead. Science of the Total Environment 427-428:253-262.
Serbula S. M., Antonijevic M. M., Milosevic N. M., Milic S. M., Ilic A. A., 2010 Concentration of particulate matter and arsenic in Bor (Serbia). Journal of Hazardous Materials 181:43-51.
Serbula S. M., Miljkovic D. D., Kovacevic R. M., Ilic A. A., 2012 Assessment of airborne heavy metal pollution using plant parts and topsoil. Ecotoxicology and Environmental Safety 76:209-214.
Shaikh I. R., Shaikh P. R., Shaikh R. A., Shaikh A. A., 2013 Phytotoxic effect of heavy metals (Cr, Cd, Mn and Zn) on wheat (*Triticum aestivum* L.) seed germination and seedlings growth in black cotton soil of Nanded, India. Research Journal of Chemical Science 3:14-23.
Viehweger K., 2014 How plants cope with heavy metals? Botanical Studies 55:2-12.
Ward N. I., 2000 Trace elements. In: Environmental analytical chemistry. Fifield F. W., Haines P. W. (eds), Blackwell, Oxford, pp. 360-392.
Williams J. R., Pillay A. E., 2011 Metals, metalloids and toxicity in date palms: potential environmental impact. Journal of Environmental Protection 2:592-600.
Yadav S. K., 2010 Heavy metal toxicity in plants: an overview on the role of glutathione and phytochelatins in heavy metal stress tolerance of plants. South African Journal of Botany 76:167-179.
Zhao K., Liu X., Xu J., Selim H. M., 2010 Heavy metal contaminations in soil-rice system: identification of spatial dependence in relation to soil properties of paddy fields. Journal of Hazardous Materials 181:778-787.

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