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Determination of Arsenic and Some Heavy Metals Levels in Roadside Soils and Leaves of Aleppo City, Syria

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The concentration of As, Pb, Cd, Cr, Ni, Cu, Mn, Fe and Zn in soils and leaves of trees (pine, cypress, quinquine, ligastrium and azedarach) on both sides of the roads in the Aleppo city *i.e.*, Bab Al-Faraj, Saadallah Al-Jabiri Square, Nile Street and Western Ring Road have been carried out using atomic absorption spectroscopy. It was found that the amount of pollution vary according to the element, location, traffic, weather conditions, population, density of buildings and the type of trees. The levels of all elements were decreased according to the mentioned sequence sites. Pollutants in leaves were as follows (ppm): As: 3.7-58; Pb: 5.8-22.4; Cd: 0.20-0.76; Cr: 1.6-3.2; Ni: 0.14-1.08; Cu: 4.5-15.8; Mn: 1.6-10.5; Fe: 20.3-62.1 and Zn: 7.5-28.1 and in the soil under the trees as follows (ppm): As: 78-618; Pb: 133-940; Cd: 5.7-30.4; Cr: 14.0-73.2; Ni: 3.8-34; Cu: 87-658; Mn: 62-436; Fe: 510-3614 and Zn: 162-1195. This study shows that the densely populated areas and buildings with heavy traffic (within the city) are strongly contaminated with arsenic and heavy metals more than other regions, which adversely affects public health. The trees planting on both sides of the streets effectively reduce the air pollutants.

Key Words: Heavy metals, Roadsides, Soil, Tree leaves, Aleppo city, Syria.

INTRODUCTION

Concentrations of Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn elements were measured in the leaves and soil of Robinia Pseudoacacia Park in the town of Olesnica, Poland as a reference site. This town was selected, because the emission from motor vehicles is practically the only source of air pollution and it seemed interesting to evaluate its influence on soil and plants[1].

Pollution by heavy metals over large areas and long periods of time may cause chronic damage to living organisms and must be carefully monitored to determine the extent of environmental contamination by measuring the levels of toxins in plants[2]. While foliage analysis is a common method for assessing the nutritional status of trees, the tree foliage is also regarded as a good environmental bioindicator and nutrient and non-essential element concentrations are used for the assessment of air and soil pollution[3,4].

As trees are very efficient at trapping atmospheric particles, which is especially important in urban areas, the use of leaves primarily as biomonitors accumulating trace metals has acquired great ecological importance[5]. Park trees are also known to absorb and accumulate airborne contaminants and therefore they have been used as longer-term air pollution indicator[6]. Park monitoring supplies low-cost information on the composition and magnitude of pollutants deposition. Road traffic contributes significantly to air pollution in urban areas, generating particulate matter, aerosols and heavy metals around roads[7,8].

Robinia pseudoacacia L. are characterized species trees in North America which can survive at high temperature range and grows in almost any type of soil. It is commonly planted in dry soil for ornamental purposes and it is extensively naturalized in Europe, Asia and Africa. It is usually found along roadsides in industrial and agricultural areas and urban parks, even with high levels of pollution. Some researchers have used *R. pseudoacacia* as a biomonitor of heavy metal pollution, for numerous reasons. It is very common in both urban and rural areas and has a wide geographical range. Sampling, identification and cultivation is easy and inexpensive, so it is recommended as a useful foliar bioindicator and as one of the species in plant barriers intercepting heavy metals of vehicular origin[7,9,10]. On the other hand, some researchers reported that *R. pseudoacacia* have low foliar heavy metal concentrations and therefore, they were proposed to be suitable for phytostabilization purposes[8,11].

Dust on tree leaves in the urban area of Hangzhou, China, was analyzed in terms of heavy metal contents and magnetic properties. Morphological and chemical composition of the dust particles were analyzed using a high resolution transmission electron microscope equipped with an energy-dispersive X-ray analyzer (HRTEM/EDX). Results indicated that the dusts contain high concentrations of Cd, Cu, Zn and Pb and they were at 2.62, 63.7, 535.9 and 150.9 ppm, respectively[12].

Some trace metals (such as Cu and Zn) at small amounts are harmless, but some (mainly Pb, As, Hg and Cd) even at extremely low concentrations are toxic and are potential cofactors, initiators or promoters in many diseases like cancer[13].

A total of 96 streets dust and 96 roadside soils have been sampled from three different localities (urban, industrial, peripheral) of the city of Kavala (Greece) and analyzed for Pb, Cu, Zn, Ni, Cr, Cd, As and Hg using atomic absorption spectrophotometric method. Results showed that, dust and soil samples from the urban and industrial area contained significant levels of the studied metals in comparison with the values from the control site. The mean values for Pb, Cu, Zn, Ni, Cr, Cd, As and Hg in street dust were at 300.9, 123.9, 271.6, 57.5, 196.0, 0.2, 16.7 and 0.1 ppm, respectively, whereas for roadside soil, the reported concentrations were at 359.4, 42.7, 137.8, 58.2, 193.2, 0.2, 62.3 and 0.1 ppm, respectively. Street dust distribution patterns are almost similar to those found for roadside soils. The obtained results indicate, that urban and industrial street dust samples contain high levels of Pb, Cu, Zn and As, as well as remarkable levels of Cd and Hg whose primary contributors appear to be vehicular local traffic and the nearby phosphoric fertilizer and petrochemical industry plants[14].

Lead in leaves of seven species of trees (*Ficus carica, Olea sativa, Pinus Sylvestrus, Cupressussem pervirens, Eucalyptus camaldulensis, Nerium oleander* and *Azedarachta indica*), at a distance of 5-8 m from main road of Raqqa city entrance[15,16] and in Damascus, Syria[17] were determined by atomic absorption spectroscopy. The lead concentrations found in dry-unwashed leaves of Raqqa city entrance ranged between 9.63-25.4, 5.76-13.20 and 4.76-10.94 ppm for the years 2006, 2007 and 2008, respectively. The levels of Pb, Cd, Cu and Zn in leafy vegetables, the tree leaves and soils in some sites in the Aleppo city[18,19] were studied.

The aim of present study is to find out the impact of pollution levels of As, Pb, Cd, Cr, Ni, Cu, Mn, Fe and Zn in soils and leaves of trees (pine, cypress, quinquine, ligastrium and azedarach) on both sides of the roads in the Aleppo city *i.e.*, Bab Al-Faraj, Saadallah Al-Jabiri Square, Nile Street and Western Ring Road using atomic absorption spectroscopy.

EXPERIMENTAL

Atomic absorption spectrometer used for analysis of elements was manufactured by Shimadzu type AA-6601 equipped with lamps type HCl particular of analysis studied elements and corrected for background reference BGC-D2K with flame (Air-C_2H_2). The analytical used lines of As, Pb, Cd, Cr, Cu, Fe and Zn were at 193.70, 217.00, 228.80, 357.87, 232.00, 324.75, 279.48, 248.33 and 213.86 nm, respectively. For samples aching, the oven (1200 ± 5 ºC) from Nabetherm was used, while another furnace (300 ± 1 ºC) from Ecocell was used for drying samples.

Sample collection and preparation: Four sampling sites were selected for this study in the Aleppo city *i.e.*, Bab Al-Faraj, Saadallah Al-Jabiri Square (in the city center; due to heavy traffic jam and narrow streets), Nile Street and Western Ring Road (less traffic jam and wide streets). 250 g of each sample from soil and leaves of trees (pine, cypress, quinquine, ligastrium and azedarach) on both sides of the roads were dried at 105 ºC, followed by crushing in a porcelain mortar, then sieved using 1 mm mesh and finally dried again and kept in polyethylene packages for next procedures. Soil samples were taken from the tree trunk of the topsoil (0-20 cm). Five leaves samples were collected from the same fields. Sampling was carried out in summer (August 2008) and winter (January 2009).

Treatment of tree leaves: Taking an appropriate quantity of powder sample and placed in the dish of platinum, added 5 mL of H_2O_2 and 0.5 mL of sulfuric acid (> 98 %) as drop by drop. The samples were heated on an electric heater with caution until the end of the drought and then transferred to the incineration furnace. The samples were placed in the furnace for 6 h at 600 ºC and then cooled under room temperature conditions and the obtained ash was dissolved with 0.25 mL of (65 %) HNO_3 (1:1), then transferred into volumetric flask volume of 10 mL and the final volume was completed to 10 mL using distilled water[15,16].

Treatment of soil: Taking an appropriate quantity of powder sample of soil (soil was cored at 0-20 cm in depth) and placed in the dish of platinum, added 5 mL of HNO_3 (1:1), then transferred into volumetric flask of 10 mL and the final volume was completed to 10 mL using distilled water[15,16].

Reference solution preparation: 25 mL of H_2O_2 and 2.5 mL of sulfuric acid were taken and placed in platinum dish and heated on an electric heater with caution until the end of the drought. Then 1.25 mL of HNO_3 solution (1:1) was added and then transferred into volumetric flask volume of 50 mL and the final volume was completed to 50 mL using distilled water.

Standard solutions preparation: Standard solutions of the following elements: As, Pb, Cd, Cr, Cu, Fe and Zn (1000 mg/L) were purchased from chemicals "GR" grade (Merck, Germany). Solutions of different elements concentrations were prepared by diluting with the previous standard solutions.

RESULTS AND DISCUSSION

In this reported study, five types of trees (pine, cypress, quinquine, ligastrium and azedarach), with the following identified elements (As, Pb, Cd, Cr, Ni, Cu, Mn, Fe and Zn) in the leaves and the soil beneath Batif have been selected and analyzed using atomic absorption. Two sites in the city of Aleppo with a densely populated places and heavy traffic density are selected (Bab Al-Faraj and Saadallah Al-Gabri sites). The third (Nile Street) site is relatively located in an open spaces and medium density of traffic. The final site (Western Ring Road) is located in an open area in the western city with approximately dozens of meters away from the residential buildings with altitude as a control site since often the wind direction from west to east.

Determination of arsenic and heavy metals in the tree leaves

Bab Al-Faraj site: The levels of arsenic and heavy metals (Pb, Cd, Cr, Ni, Cu, Mn, Fe and Zn) in the leaves of tree (pine, cypress, quinquine, ligastrium and azedarach) in the area of the Bab Al-Faraj site were very high. The amount of pollution varies depending on the type of trees and element contaminated; whereas decreases in according to the mentioned sequence of trees. Levels of pollution decrease as follows: Fe, As, Zn, Pb, Cu, Mn, Cr, Ni and Cd. Table-1 shows that the amounts of elements: As, Pb, Cd, Cr, Ni, Cu, Mn, Fe and Zn in the studied region of the Bab Al-Faraj were in summer at 44.1 to 58.0, 13.0 to 22.4, 0.431 to 0.760, 2.41 to 3.20, 1.00 to 1.08, 8.7 to 15.8, 9.6 to 10.5, 45.8 to 62.2 and 15.7 to 28.1 ppm and in winter at 31.4 to 40.8, 12.6 to 18.6, 0.430 to 0.632, 1.97 to 2.86, 0.92 to 0.98, 9.1 to 13.6, 8.2 to 8.8, 43.9 to 57.1 and 15.8 to 23.9 ppm, respectively.

Saadallah Al-Gabri Square site: The studied leaves pollutants in the region Saadallah al-Jabiri Square site with arsenic and heavy metals were also high and decreased the amount of pollution in according to the mentioned sequence of trees: Pine, Cypress, Quinquine, Ligastrium and Azedarach. Cadmium was also a little compared with the other studied pollutants. The amount of pollution decreasing according to the following sequence: Fe, As, Zn, Pb, Cu, Mn, Cr, Ni and Cd (Table-2).

TABLE-1
DETERMINATION OF ELEMENT LEVELS (As, Pb, Cd, Cr, Ni, Cu, Mn, Fe AND Zn) IN TREES LEAVES (PINE, CYPRESS, QUINQUINE, LIGASTRIUM AND AZEDARACH) ON BOTH SIDES OF THE STREETS IN THE ALEPPO CITY: BAB AL-FARAJ SITE USING ATOMIC ABSORPTION SPECTROSCOPY

Element	Sampling time	$\left(\overline{X} \pm \frac{SD}{\sqrt{n}} \times t\right)^*$ (ppm)				
		Pine	Cypress	Quinquine	Ligastrium	Azedarach
As	Summer	58.0±2.13	55.8±2.06	46.1±1.71	44.5±1.64	44.1±1.63
	Winter	40.8±1.57	39.2±1.53	32.0±1.25	31.4±1.23	ND
Pb	Summer	22.4±0.81	20.8±0.75	15.4±0.57	14.8±0.55	13.0±0.50
	Winter	18.6±0.69	17.7±0.65	12.8±0.49	12.6±0.48	ND
Cd	Summer	0.760±0.009	0.710±0.008	0.532±0.006	0.470±0.006	0.431±0.005
	Winter	0.632±0.007	0.620±0.007	0.571±0.007	0.430±0.005	ND
Cr	Summer	3.20±0.095	3.11±0.093	2.80±0.084	2.53±0.082	2.41±0.080
	Winter	2.86±0.085	2.80±0.084	2.03±0.075	1.97±0.073	ND
Ni	Summer	1.08±0.030	1.06±0.030	1.02±0.029	1.01±0.029	1.00±0.029
	Winter	0.98±0.028	0.97±0.028	0.95±0.027	0.92±0.027	ND
Cu	Summer	15.8±0.29	15.3±0.28	10.9±0.22	10.7±0.23	8.7±0.21
	Winter	13.6±0.25	13.4±0.25	9.3±0.18	9.1±0.19	ND
Mn	Summer	10.5±0.37	10.3±0.37	10.0±0.35	9.8±0.33	9.6±0.32
	Winter	8.8±0.29	8.7±0.29	8.5±0.28	8.2±0.26	ND
Fe	Summer	62.2±1.23	61.3±1.21	48.0±1.06	47.2±1.05	45.8±1.04
	Winter	57.1±1.19	56.4±1.18	44.6±1.03	43.9±1.02	ND
Zn	Summer	28.1±0.63	25.9±0.61	19.3±0.50	18.5±0.48	15.7±0.43
	Winter	23.9±0.56	23.4±0.55	16.5±0.45	15.8±0.45	ND

*n = 5, t = 2.776.

It is clearly observed from Table-2 that the amount of elements: As, Pb, Cd, Cr, Ni, Cu, Mn, Fe and Zn in Saadallah Al-Jabiri Square site were in summer at 42.2 to 49.9, 11.2 to 18.5, 0.362 to 0.632, 1.90 to 2.70, 0.87 to 0.92, 8.6 to 12.7, 8.2 to 8.6, 34.0 to 51.2 and 13.3 to 23.3 ppm and in winter at 30.3 to 39.2, 9.6 to 14.8, 0.342 to 0.521, 1.81 to 2.31, 0.79 to 0.82, 7.1 to 10.5, 7.1 to 7.5, 35.6 to 46.7 and 12.3 to 19.8 ppm, respectively.

Nile Street site: The pollution in studied leaves in the Nile Street with arsenic and heavy metals was lower than of the city center and the levels of pollution decrease as follows: Fe, As, Zn, Pb, Cu, Mn, Cr, Ni and Cd (Table-3). The concentration of elements: As, Pb, Cd, Cr, Ni, Cu, Mn, Fe and Zn in Nile Street site were in summer at 20.2 to 30.2, 6.8 to 11.5, 0.238 to 0.401, 1.03 to 1.74, 0.51 to 0.54, 4.6 to 8.1, 4.7 to 5.1, 24.8 to 31.9 and 8.2 to 14.7 ppm and in winter at 21.0 to 26.9, 5.8 to 9.7, 0.208 to 0.332, 1.03 to 1.50, 0.43 to 0.48, 4.5 to 6.3, 4.1 to 4.3, 23.7 to 29.0 and 7.5 to 12.3 ppm, respectively. Table-3 shows that, the amounts of all studied pollutants in summer were also more than in winter, the greatest amount of contaminants found in leaves of pine trees and the smaller amount in leaves of azedarach trees.

TABLE-2
DETERMINATION OF ELEMENT LEVELS (As, Pb, Cd, Cr, Ni, Cu, Mn, Fe AND Zn) IN TREES LEAVES (PINE, CYPRESS, QUINQUINE, LIGASTRIUM AND AZEDARACH) ON BOTH SIDES OF THE STREETS IN THE ALEPPO CITY: SAADALLAH AL-JABIRI SQUARE SITE USING ATOMIC ABSORPTION SPECTROSCOPY

Element	Sampling time	$\left(\overline{X} \pm \frac{SD}{\sqrt{n}} \times t\right)$* (ppm)				
		Pine	Cypress	Quinquine	Ligastrium	Azedarach
As	Summer	49.9±1.92	53.9±2.07	44.8±1.70	42.5±1.60	42.2±1.58
	Winter	39.2±1.51	38.1±1.50	30.9±1.45	30.3±1.43	ND
Pb	Summer	18.5±0.67	16.6±0.62	13.1±0.50	12.1±0.48	11.2±0.46
	Winter	14.8±0.57	13.5±0.54	10.3±0.42	9.6±0.41	ND
Cd	Summer	0.632±0.007	0.601±0.007	0.450±0.005	0.384±0.005	0.362±0.004
	Winter	0.521±0.006	0.512±0.006	0.480±0.006	0.342±0.004	ND
Cr	Summer	2.70±0.083	2.58±0.082	2.16±0.080	2.03±0.078	1.90±0.077
	Winter	2.31±0.081	2.28±0.081	1.84±0.059	1.81±0.058	ND
Ni	Summer	0.92±0.027	0.91±0.026	0.90±0.026	0.88±0.025	0.87±0.025
	Winter	0.82±0.028	0.82±0.028	0.80±0.027	0.79±0.027	ND
Cu	Summer	12.7±0.25	12.5±0.25	8.7±0.21	8.6±0.21	7.4±0.19
	Winter	10.5±0.23	10.3±0.23	7.9±0.21	7.1±0.19	ND
Mn	Summer	8.6±0.28	8.5±0.27	8.4±0.27	8.3±0.26	8.2±0.26
	Winter	7.5±0.24	7.4±0.24	7.2±0.23	7.1±0.23	ND
Fe	Summer	51.2±1.14	50.8±1.12	39.7±0.098	38.2±0.097	34.0±0.082
	Winter	46.7±1.04	45.3±1.03	36.4±0.095	35.6±0.092	-
Zn	Summer	23.3±0.55	21.6±0.54	16.2±0.44	14.4±0.39	13.3±0.38
	Winter	19.8±0.49	18.7±0.49	13.5±0.39	12.3±0.37	ND

*n = 5, t = 2.776.

Western Ring Road: The arsenic and heavy metals in the leaves in the Western Ring Road, were lower with about 5 times than in the city center and also about 3 times lower than in the Nile Street (Table-4). The amount of pollution of elements: As, Pb, Cd, Cr, Ni, Cu, Mn, Fe and Zn in Western Ring Road site were in summer at 7.1 to 9.0, 2.4 to 4.3, 0.141 to 0.250, 0.241 to 0.542, 0.19 to 0.21, 1.62 to 3.20, 2.0 to 2.3, 9.34 to 12.9 and 3.2 to 5.4 ppm and in winter at 6.0 to 7.9, 2.4 to 3.7, 0.147 to 0.213, 0.310 to 0.460, 0.14 to 0.16, 1.49 to 2.81, 1.6 to 1.8, 7.24 to 10.5 and 3.5 to 4.8 ppm, respectively. Table-4 shows that, the amounts of all studied pollutants in summer were also more than in winter, the greatest amount of contaminants found in leaves of pine trees and the smaller amount in leaves of alozdrecht trees and the greatest amount of pollutant elements was for iron and the smaller amount for cadmium.

Determination of arsenic and heavy metals in the soil under the trees

Bab Al-Faraj site: The pollution of the soil under the trees (pine, cypress, quinquine, ligastrium and azedarach) available in the area of the Bab Al-Faraj site with arsenic and heavy metals were too high. The quantity varies depending on the

TABLE-3
DETERMINATION OF ELEMENT LEVELS (As, Pb, Cd, Cr, Ni, Cu, Mn, Fe AND Zn) IN TREES LEAVES (PINE, CYPRESS, QUINQUINE, LIGASTRIUM AND AZEDARACH) ON BOTH SIDESOF THE STREETS IN THE ALEPPO CITY: NILE STREET SITE USING ATOMIC ABSORPTION SPECTROSCOPY

Element	Sampling time	$\left(\overline{X} \pm \frac{SD}{\sqrt{n}} \times t\right)$* (ppm)				
		Pine	Cypress	Quinquine	Ligastrium	Azedarach
As	Summer	30.2±1.43	29.4±1.42	23.6±1.14	23.1±1.12	20.2±0.97
	Winter	26.9±1.26	26.6±1.23	21.4±0.97	21.0±0.96	ND
Pb	Summer	11.5±0.46	10.8±0.43	7.9±0.32	7.6±0.31	6.8±0.29
	Winter	9.7±0.39	8.7±0.36	6.4±0.27	5.8±0.25	ND
Cd	Summer	0.401±0.005	0.384±0.005	0.280±0.003	0.260±0.003	0.238±0.003
	Winter	0.332±0.004	0.314±0.004	0.236±0.003	0.208±0.003	ND
Cr	Summer	1.74±0.056	1.68±0.053	1.25±0.045	1.20±0.043	1.03±0.040
	Winter	1.50±0.050	1.49±0.049	1.08±0.041	1.03±0.040	ND
Ni	Summer	0.54±0.020	0.54±0.020	0.53±0.019	0.52±0.019	0.51±0.018
	Winter	0.48±0.017	0.47±0.017	0.45±0.016	0.43±0.016	ND
Cu	Summer	8.1±0.19	8.0±0.19	5.7±0.15	5.2±0.14	4.6±0.13
	Winter	6.3±0.17	6.1±0.17	4.9±0.15	4.5±0.15	ND
Mn	Summer	5.1±0.20	5.1±0.20	5.0±0.19	4.8±0.18	4.7±0.18
	Winter	4.3±0.17	4.2±0.17	4.2±0.16	4.1±0.16	ND
Fe	Summer	31.9±0.67	31.0±0.66	26.7±0.58	26.2±0.58	24.8±0.57
	Winter	29.0±0.62	28.4±0.60	24.0±0.57	23.7±0.56	ND
Zn	Summer	14.7±0.40	14.2±0.39	10.0±0.29	9.6±0.27	8.2±0.24
	Winter	12.3±0.35	11.7±0.33	8.6±0.26	7.5±0.23	ND

*n = 5, t = 2.776.

type of trees; whereas decreases in according to the following sequence of trees: azedarach, cypress, pine, quinquine and ligastrium and contaminated elements. The greatest amount of pollutant elements was for iron and the smaller amount for cadmium (Table-5). The amounts of elements: As, Pb, Cd, Cr, Ni, Cu, Mn, Fe and Zn in the studied region of the Bab Al-Faraj were in summer at 440 to 560, 620 to 810, 19.4 to 25.6, 50 to 68, 19 to 29, 441 to 575, 331 to 361, 2434 to 3318 and 812 to 1048 ppm and in winter at 467 to 618, 680 to 940, 21.8 to 30.4, 55 to 73, 21 to 34, 493 to 658, 337 to 436, 2806 to 3614 and 899 to 1195 ppm, respectively. Table-5 shows that, the amounts of all studied pollutants in winter were more than in summer.

Saadallah Al-Gabri Square site: The pollution of the soil under the above mentioned trees located in the Saadallah Al-Gabri Square site with arsenic and heavy metals was also considerable. The quantity varies depending on the type of trees and contaminated elements; whereas decreases in according to the following sequence of trees: azedarach, cypress, pine, quinquine and ligastrium. Cadmium is also less compared with the other studied pollutants (Table-6). The levels of soil contamination with the following studied elements: As, Pb, Cd, Cr, Ni, Cu, Mn, Fe and Zn in the Saadallah Al-Jaberi Square site were in summer at 340 to 451, 512 to

TABLE-4
DETERMINATION OF ELEMENT LEVELS (As, Pb, Cd, Cr, Ni, Cu, Mn, Fe AND Zn) IN TREES LEAVES (PINE, CYPRESS, QUINQUINE, LIGASTRIUM AND AZEDARACH) ON BOTH SIDES OF THE STREETS IN THE ALEPPO CITY: WESTERN RING ROAD SITE USING ATOMIC ABSORPTION SPECTROSCOPY

Element	Sampling time	$\left(\overline{X} \pm \frac{SD}{\sqrt{n}} \times t\right)^*$ (ppm)				
		Pine	Cypress	Quinquine	Ligastrium	Azedarach
As	Summer	9.0±0.42	8.9±0.41	7.4±0.35	7.2±0.34	7.1±0.33
	Winter	7.9±0.39	7.8±0.38	6.1±0.30	6.0±0.30	ND
Pb	Summer	4.3±0.20	4.1±0.19	2.8±0.14	2.6±0.13	2.4±0.12
	Winter	3.7±0.17	3.5±0.17	2.5±0.12	2.4±0.12	ND
Cd	Summer	0.250±0.003	0.238±0.003	0.170±0.002	0.162±0.002	0.141±0.002
	Winter	0.213±0.003	0.206±0.003	0.152±0.002	0.147±0.002	ND
Cr	Summer	0.542±0.021	0.531±0.020	0.402±0.014	0.389±0.014	0.241±0.010
	Winter	0.460±0.016	0.448±0.015	0.327±0.013	0.310±0.011	ND
Ni	Summer	0.21±0.011	0.21±0.011	0.20±0.011	0.20±0.011	0.19±0.010
	Winter	0.16±0.009	0.15±0.008	0.15±0.008	0.14±0.008	ND
Cu	Summer	3.20±0.083	3.01±0.078	2.24±0.062	1.98±0.057	1.62±0.052
	Winter	2.81±0.076	2.76±0.074	1.90±0.056	1.49±0.045	ND
Mn	Summer	2.3±0.12	2.2±0.12	2.1±0.11	2.1±0.11	2.0±0.11
	Winter	1.8±0.10	1.8±0.10	1.7±0.09	1.6±0.09	ND
Fe	Summer	12.9±0.40	12.6±0.38	9.82±0.30	9.53±0.29	9.34±0.28
	Winter	10.5±0.33	10.3±0.32	7.97±0.27	7.24±0.25	ND
Zn	Summer	5.4±0.17	5.2±0.16	4.1±0.14	4.0±0.13	3.2±0.11
	Winter	4.8±0.15	4.6±0.15	3.7±0.13	3.5±0.12	ND

*n = 5, t = 2.776.

674, 16.0 to 21.3, 47 to 56, 16 to 24, 362 to 480, 298 to 334, 2404 to 2745 and 670 to 870 ppm and in winter at 392 to 510, 570 to 775, 18.0 to 24.7, 49 to 62, 18 to 31, 403 to 550, 301 to 380, 2416 to 3014 and 744 to 998 ppm, respectively. Table-6 shows that the amounts of all studied pollutants in winter were also more than in summer, the greatest amount of contaminants found in soil under the alozdrecht trees and the smaller amount under the ligastrium trees and the greatest amount of pollutant elements was iron and the smaller amount was cadmium.

Nile Street site: The pollution of the soil under the studied trees in Nile Street site, with arsenic and heavy metals is now clearly less than the case in the area of the Bab Al-Faraj and Saadallah Al-Gabri Square. Table-7 shows that the levels of contamination soil with studied arsenic and heavy metals in Nile Street site were less than in Bab Al-Faraj site at about 2 times. The levels of contamination soil with studied elements: As, Pb, Cd, Cr, Ni, Cu, Mn, Fe and Zn in the Nile Street site were in summer at 223 to 274, 308 to 407, 9.6 to 13.1, 24 to 35, 9.6 to 14, 218 to 280, 170 to 197, 1202 to 1628 and 402 to 530 ppm and in winter at 239 to 312, 345 to 473, 11.0 to 15.3, 27 to 37, 10 to 18, 249 to 332, 175 to 228, 1400 to 1812 and 443 to 603 ppm, respectively. The results shows that the amounts of all studied pollutants in

TABLE-5
DETERMINATION OF ELEMENT LEVELS (As, Pb, Cd, Cr, Ni, Cu, Mn, Fe AND Zn) IN SOIL UNDER THE TREES (PINE, CYPRESS, QUINQUINE, LIGASTRIUM AND AZEDARACH) ON BOTH SIDES OF THE STREETS IN THE ALEPPO CITY: BAB AL-FARAJ SITE USING ATOMIC ABSORPTION SPECTROSCOPY

Element	Sampling time	$\left(\bar{X} \pm \frac{SD}{\sqrt{n}} \times t\right)^*$ (ppm)				
		Pine	Cypress	Quinquine	Ligastrium	Azedarach
As	Summer	468±11.6	486±12.1	455±11.9	440±11.8	560±13.6
	Winter	510±12.6	532±12.9	498±12.0	467±11.9	618±15.3
Pb	Summer	705±18.4	723±18.8	694±17.7	620±17.7	810±19.1
	Winter	780±19.4	803±15.3	768±19.1	680±18.5	940±21.0
Cd	Summer	21.9±0.23	22.3±0.24	21.7±0.23	19.4±0.21	25.6±0.26
	Winter	24.8±0.26	25.6±0.26	24.2±0.25	21.8±0.23	30.4±0.31
Cr	Summer	54±1.44	57±1.50	53±1.42	50±1.36	68±1.73
	Winter	61±1.59	64±1.64	59±1.54	55±1.46	73±1.81
Ni	Summer	21±0.57	21±0.57	20±0.56	19±0.55	29±0.65
	Winter	25±0.63	24±0.61	23±0.59	21±0.57	34±0.78
Cu	Summer	498±5.2	515±5.4	490±5.2	441±4.8	575±5.8
	Winter	558±5.7	577±5.8	540±5.6	493±5.2	658±6.5
Mn	Summer	338±8.1	337±8.0	334±7.9	331±7.7	361±8.8
	Winter	342±8.5	340±8.4	339±8.3	337±8.1	436±9.2
Fe	Summer	2710±45.3	2640±44.1	2462±42.5	2434±42.3	3318±50.5
	Winter	2975±47.2	3081±47.9	2892±46.7	2806±46.0	3614±53.8
Zn	Summer	913±9.2	946±9.5	897±9.1	812±8.4	1048±10.3
	Winter	1020±10.1	1051±10.3	994±10.0	899±9.1	1195±11.6

*n = 5, t = 2.776.

winter were also more than in summer, the greatest amount of contaminants found in soil under the azedarach trees and the smaller amount under the ligastrium trees and the greatest amount of pollutant element was iron and the smaller amount was cadmium.

Western Ring Road site: The levels of pollutants in the soil under the studied trees in the Western Ring Road site with arsenic and heavy metals were very low (about 5 times) in comparison with levels within the city center. The quantity varies depending on the type of trees. The greatest amount of contaminants were found in soil under the azedarach trees and the smaller amount under the ligastrium trees. The highest contaminated elements amount of pollutant was iron and the smaller amount was cadmium (Table-8). The levels of contamination soil with studied elements: As, Pb, Cd, Cr, Ni, Cu, Mn, Fe and Zn in the Western Ring Road site were in summer at 86 to 114, 133 to 174, 5.70 to 7.52, 9.2 to 14.1, 3.8 to 5.6, 87 to 120, 62 to 84, 480 to 658 and 162 to 211 ppm and in winter at 92 to 123, 150 to 206, 6.31 to 8.72, 11.0 to 14.9, 4.3 to 7.3, 98 to 135, 65 to 101, 554 to 703 and 184 to 251 ppm, respectively. The results show that the amounts of all studied pollutants in winter were also more than in summer.

TABLE-6
DETERMINATION OF ELEMENT LEVELS (As, Pb, Cd, Cr, Ni, Cu, Mn, Fe AND Zn) IN SOIL UNDER THE TREES (PINE, CYPRESS, QUINQUINE, LIGASTRIUM AND AZEDARACH) ON BOTH SIDES OF THE STREETS IN THE ALEPPO CITY: SAADALLAH AL-JABIRI SQUARE SITE USING ATOMIC ABSORPTION SPECTROSCOPY

Element	Sampling time	$\left(\overline{X} \pm \frac{SD}{\sqrt{n}} \times t\right)$* (ppm)				
		Pine	Cypress	Quinquine	Ligastrium	Azedarach
As	Summer	387±10.3	409±10.9	365±10.0	340±9.7	451±11.9
	Winter	442±11.8	453±11.9	432±11.7	392±10.5	510±12.6
Pb	Summer	583±15.9	608±16.6	569±16.2	512±15.2	674±17.5
	Winter	654±16.8	668±18.2	640±16.7	570±16.4	775±19.2
Cd	Summer	18.3±0.20	18.7±0.20	18.2±0.20	16.0±0.19	21.3±0.23
	Winter	20.6±0.22	21.4±0.23	20.1±0.22	18.0±0.20	24.7±0.26
Cr	Summer	52±1.42	55±1.46	50±1.40	47±1.35	56±1.48
	Winter	55±1.46	57±1.50	54±1.45	49±1.38	62±1.59
Ni	Summer	18±0.53	17±0.51	17±0.51	16±0.49	24±0.61
	Winter	20±0.56	20±0.56	19±0.55	18±0.53	31±0.71
Cu	Summer	415±4.6	430±4.7	409±4.5	362±4.0	480±5.1
	Winter	465±5.0	480±5.1	450±4.9	403±4.4	550±5.7
Mn	Summer	302±6.5	301±6.4	300±6.4	298±6.3	334±7.9
	Winter	306±6.6	304±6.6	302±6.5	301±6.4	380±8.2
Fe	Summer	2458±43.6	2454±43.8	2410±42.2	2404±42.1	2745±45.6
	Winter	2697±44.3	2735±45.4	2592±44.0	2416±42.2	3014±47.0
Zn	Summer	760±7.9	783±8.1	745±7.8	670±7.1	870±8.8
	Winter	848±8.7	875±8.9	825±8.6	744±7.8	998±9.9

*n = 5, t = 2.776.

Effect of wind direction on the pollution of the soil under the trees: The effect of wind direction on the pollution of soil under the trees in the parks adjacent to the street in the city center was studied. It was found that the amount of pollution to be great in the vicinity of the tree, a distance of about 1 m from its center and then decreasing to stay stable from the tree. A sharp decrease was in the west planted trees in comparison with east planted trees (wind direction from west to east), while the decrease in the south and north of the tree almost similar.

Conclusion

The identification of the levels of arsenic and some heavy metals in soil and tree leaves on both sides of the roads in the city of Aleppo, Syria has shown that, the amount of pollutants vary according to the specific metal with the factors such as the site and location, intensity of traffic, weather conditions (the movement and high speed of wind, moisture, rainfall), density of population, the types of trees, buildings and high traffic jam (within the city). It is recommended that, the trees planting on both sides of the streets effectively reduce the air pollutants.

TABLE-7
DETERMINATION OF ELEMENT LEVELS (As, Pb, Cd, Cr, Ni, Cu, Mn, Fe AND Zn) IN SOIL UNDER THE TREES (PINE, CYPRESS, QUINQUINE, LIGASTRIUM AND AZEDARACH) ON BOTH SIDES OF THE STREETS IN THE ALEPPO CITY: NILE STREET SITE USING ATOMIC ABSORPTION SPECTROSCOPY

Element	Sampling time	$\left(\bar{X} \pm \frac{SD}{\sqrt{n}} \times t\right)$* (ppm)				
		Pine	Cypress	Quinquine	Ligastrium	Azedarach
As	Summer	238±6.8	250±7.2	230±6.5	223±6.4	274±7.8
	Winter	261±7.5	270±7.7	250±7.2	239±6.8	312±8.5
Pb	Summer	354±12.3	364±12.2	346±12.0	308±11.1	407±13.1
	Winter	392±13.1	404±13.0	385±13.4	345±12.4	473±14.7
Cd	Summer	11.0±0.13	11.2±0.13	10.9±0.13	9.6±0.11	13.1±0.15
	Winter	12.6±0.15	13.0±0.15	12.4±0.14	11.0±0.13	15.3±0.17
Cr	Summer	27±0.96	29±1.02	26±0.91	24±0.86	35±1.20
	Winter	31±1.11	33±1.15	30±1.05	27±0.96	37±1.23
Ni	Summer	10±0.36	10±0.36	9.8±0.35	9.6±0.35	14±0.40
	Winter	12±0.38	12±0.38	11±0.37	10±0.36	18±0.53
Cu	Summer	251±2.8	260±2.9	242±2.7	218±2.4	280±3.1
	Winter	280±3.1	292±3.3	276±3.1	249±2.8	332±3.7
Mn	Summer	176±3.9	175±3.9	173±3.8	170±3.7	197±4.2
	Winter	180±4.1	179±4.1	177±4.0	175±3.9	228±4.5
Fe	Summer	1403±26.4	1330±25.0	1214±23.4	1202±23.3	1628±28.4
	Winter	1501±28.1	1597±29.5	1464±26.9	1400±26.4	1812±31.5
Zn	Summer	464±5.0	491±5.3	450±4.9	402±4.4	530±5.7
	Winter	510±5.5	575±6.1	500±5.4	443±4.8	603±6.4

*n = 5, t = 2.776.

TABLE-8
DETERMINATION OF ELEMENT LEVELS (As, Pb, Cd, Cr, Ni, Cu, Mn, Fe AND Zn) IN SOIL UNDER THE TREES (PINE, CYPRESS, QUINQUINE, LIGASTRIUM AND AZEDARACH) ON BOTH SIDES OF THE STREETS IN THE ALEPPO CITY: WESTERN RING ROAD SITE USING ATOMIC ABSORPTION SPECTROSCOPY

Element	Sampling time	$\left(\bar{X} \pm \frac{SD}{\sqrt{n}} \times t\right)$* (ppm)				
		Pine	Cypress	Quinquine	Ligastrium	Azedarach
As	Summer	92±2.9	96±3.0	90±2.9	86±2.8	114±3.6
	Winter	104±3.2	112±3.5	100±3.2	92±2.9	123±4.0
Pb	Summer	151±4.9	157±5.1	148±5.0	133±4.3	174±5.4
	Winter	170±5.3	175±5.4	165±5.3	150±5.0	206±4.7
Cd	Summer	6.40±0.066	6.81±0.069	6.43±0.067	5.70±0.0.060	7.52±0.076
	Winter	7.32±0.083	7.50±0.076	7.13±0.073	6.31±0.067	8.72±0.098
Cr	Summer	10.1±0.34	11.0±0.34	10.0±0.32	9.2±0.30	14.1±0.43
	Winter	12.3±0.37	13.0±0.38	12.2±0.37	11.0±0.34	14.9±0.45
Ni	Summer	4.1±0.16	4.0±0.16	3.9±0.16	3.8±0.16	5.6±0.17
	Winter	4.7±0.17	4.6±0.17	4.5±0.17	4.3±0.17	7.3±0.18

Cu	Summer	108±1.25	115±1.31	96±1.11	87±1.02	120±1.34
	Winter	121±1.37	124±1.38	108±1.23	98±1.13	135±1.49
Mn	Summer	66±1.9	65±1.8	63±1.8	62±1.8	84±2.0
	Winter	70±2.0	69±2.0	67±1.9	65±1.9	101±2.1
Fe	Summer	540±11.9	550±12.0	486±11.4	480±11.3	658±13.7
	Winter	597±12.8	621±13.2	580±12.4	554±12.1	703±14.0
Zn	Summer	185±2.11	193±2.18	181±2.06	162±1.89	211±2.33
	Winter	210±2.33	220±2.43	204±2.30	184±2.10	251±2.74

*n = 5, t = 2.776.

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REFERENCES

1. A. Samecka-Cymerman, A. Stankiewicz, K. Kolon and A.J. Kempers, *Environ. Pollut.*, **157**, 2061 (2009).
2. D. Ceburnis and E. Steinnes, *Atmos. Environ.*, **34**, 4265 (2000).
3. P. Schleppi, L. Tobler, J.B. Bucher and A. Yttenbach, *Plant Soil*, **219**, 251 (2000).
4. M.V. Kozlov, *Environ. Pollut.*, **135**, 91 (2005).
5. M. Tomasevic, Z.Vukmirovic, S. Rajsic, M. Tasic and B. Stevanovic, *Chemosphere*, **61**, 753 (2005).
6. L. Harju, K.E. Saarela, J. Rajander, J.O. Lill, A. Lindroos and S.J. Heselius, *Nucl. Instrum. Meth. B*, **189**, 163 (2002).
7. G. Campo, M. Orsi, G. Badino, R. Giacomelli and P. Spezzano, *Sci. Total Environ.*, **189/190**, 161 (1996).
8. G. Baycu, D. Tolunay, H. Ozden and S. Gunebakan, *Environ. Pollut.*, **143**, 545 (2006).
9. F. Bussotti, P. Grossoni, P. Batistoni, M. Ferreti and E. Cenni, *Aerobiologia*, **11**, 11 (1995).
10. A. Aksoy, U. Sahin and F. Duman, *Turk. J. Bot.*, **24**, 279 (2000).
11. J. Mertens, P. Vervaeke, A. De Schrijver and S. Luyssaert, *Sci. Total Environ.*, **326**, 209 (2004).
12. S.G. Lu, Y.W. Zheng and S.Q. Bai, *Atmos. Environ.*, **42**, 6431 (2008).
13. S. Willers, L. Gerhardsson and T. Lundh, *Respiratory Medcine*, **99**, 1521 (2005).
14. A. Christoforidis and N. Stamatis, *Geoderma*, **151**, 257 (2009).
15. A.A. Ramadan and A.A. Jagle, *Res. J. Aleppo Univ., Syria*, **54**, 37 (2007).
16. A.A. Jagle, Ph.D. Thesis in Chemistry, Aleppo University, Syria (2007).
17. I. Othman, M. Al-Oudat and M.S. Al-Masri, *Sci. Total Environ.*, **207**, 43 (1997).
18. A.A. Ramadan and H. Mandil, *Asian J. Chem.*, **21**, 3243 (2009).
19. A.A. Ramadan and H. Mandil, *Res. J. Aleppo Univ., Syria*, (in press).

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