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Letter to Editor

Determination of Heavy Metal Pollution in Grass and Soil of City Centre Green Areas (Konya, Turkey)

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Abstract

This research was conducted to determine levels of heavy metal pollution in the years 2003-04. In this research, samples of grass and soil taken from green areas in 8 different areas of Konya city centre were used as material. The samples were obtained from factory gardens, areas experiencing heavy traffic and residential areas. The changes in analysis results of heavy metal levels (Pb, Cu, Zn, Co, Cr, V, Cd and Ni) in the samples were discussed for sampling years and sampling places in both grass and soil samples. The results of the study showed that heavy metal contents in both soil and grass samples were higher in 2004 than in 2003. In this study, some heavy metal content in the samples obtained in areas with heavy traffic and in factory garden areas was over the limit levels (5.67 ppm for Pb in soil and 10.69, 27.51 and 0.19 ppm for Cu, Cr and Cd in grass, respectively) and represents a risk for humans.

Keywords: heavy metals, environmental pollution, grass, soil, green areas

Introduction

Global industrialization and human social and agricultural activities have an effect on environmental pollution and the global ecosystem. This corruption of the ecosystem has a negative effect on human health and on all living organisms. Growing industrialization and environmental pollution from technology have started to affect human health [1]. Air pollution is aesthetically offensive and can be a genuine health hazard to humans as well as to vegetation [2]. The level of environmental pollution in some areas of Turkey is alarmingly high and is a national problem. Air pollution is the most important problem in the main city centers. One of the cities with the heaviest air pollution is Konya, especially during the winter period [3]. Sulphur dioxide concentration increased on some winter days to over 200 mg m^{-3}, as did particle matter in the air parallel to SO_2 concentration on the same days, due to usage of low-quality fuels for heating systems. Power plants, refineries and domestic fuel usage are major contributors, and additional SO_2 is released into the air when certain ores of nickel, copper, lead and iron are smelted [4, 5].

Pollution of the environment with toxic metals has increased dramatically since the onset of the industrial revolution [6]. Soil pollution by heavy metals, such as cadmium, lead, chromium, and copper, etc. is a problem of concern. Although heavy metals are naturally present in soil, contamination and comes, from local sources: mostly industry (mainly non-ferrous industries, but also power

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plants and iron, steel and chemical industries), agriculture (irrigation with polluted waters, sewage sludge and fertilizer, especially phosphates, contaminated manure and pesticide containing heavy metals), waste incineration, combustion of fossil fuels and road traffic. Long-range transport of atmospheric pollutants adds to the metals in the natural environment [7]. In recent years, it has been shown that lead levels in soil and vegetation have increased considerably due to traffic pollution, especially from usage of leaded petrol and exhaust combustion [8-13]. The problem worsens as daily traffic increases [14]. Recently, a report was produced which confirmed that the main source of pollution in urban areas of Turkey was traffic using leaded petrol [15].

Heavy metals can be found generally at trace levels in soil and vegetation, and living organisms feel the need for micro-elements of these metals. However, these have a toxic effect on organisms at high content levels. Heavy metal toxicity has an inhibitory effect on plant growth, enzymatic activity, stoma function, photosynthesis activity and accumulation of other nutrient elements, and also damages the root system [16].

There are limited studies on environmental pollution by heavy metals in Turkey. The investigation of [17] showed that Pb accumulation in the grass growing near a main road junction in Ankara increased during a 6-month experimental period [18]. Analyzed samples collected from seven different sampling points in Sivas city during the months of June and July to show the environmental pollution effect of heavy metal levels in plant materials indicated that heavy metal content was as follows: Zn, 12.4, Pb 6.8, Ni 6.8, Cu 5.5 and Cd 0.2 $\mu g\ g^{-1}$ in plant material. The results showed that all metal values may be found in industrial regions. A similar investigation in Erzurum [19] showed that Pb and Cu are important environmental problems in the winter period but that there was no problem with Zn.

According to Aksoy and Ozturk [20], the data for all elements (Pb, Zn, Cu and Cd) show an increase in their content with increased urbanization. The high heavy metal content in urban roadside and urban side soil and plant samples is mostly due to the density of traffic, which is considered one of the major sources of heavy metal contamination, especially of Pb, because unleaded petrol is expensive and people use leaded petrol instead. Lead was the major source of heavy metal pollution in Antalya city.

Environmentally hazardous matters have been emitted into the atmosphere from factories, building heating systems and motor vehicles using fossil fuels. The effect of air containing hazardous matter varies with chimney height, climatic factors, topographic layout, and wind direction and speed [3].

Botanical materials such as fungi, lichens, tree bark, tree rings, grass, leaves of higher plants and soil samples have been used to detect the deposition, accumulation and distribution of metal pollution [21]. The monitoring of levels of atmospheric trace metallic content by using different types has been reported [22-24]. Heavy metals are emitted into the environment in different ways, i.e. transportation, industry, fossil fuels, agriculture and other human activities [26]. The most economical and reasonable method for monitoring heavy metal levels in the atmosphere is using vegetation and soil samples. Scots pines [19], acacia [25], grass [23], other plants [26], and other organisms such as fish [27] have also been used for monitoring.

The dispersion of contaminants is influenced by meteorological conditions like wind, rainfall, profiles [29] or by traffic intensity [30]. The content of metals in the roadside soil is influenced by the same factors [30.31] and by soil parameters. In order to asses contamination by metals in the vicinity of a highway, several studies have been carried out dealing with the different compartments: study of global deposits, roadside soil and *Graminaceae* [29].

The aim of the present study was to demonstrate the factors affecting human health with analysis of soil and grass samples collected from industrial areas and areas of heavy traffic in the city centre of Konya during the period December 2003 to April 2004.

Materials and Methods

Experimental Site

The study area, Konya, is located in the central region of Turkey. Konya is an industrial and agricultural city with a population of about 800,000 inhabitants. The city, situated 1,020m above sea level, has a continental climate in which the winters are cold and usually snowy and the summers are dry and hot. The mean traffic density in the streets with heavy, medium, light and low traffic in Konya city is 1,000 vehicle/h. Konya has three central districts: Selcuklu, Karatay and Meram.

Experimental samples of grass species (mostly *Lolium perenne L.*) and soils were supplied from eight sampling points in Konya city center. The main characteristics of points selected for sampling are the following (Fig. 1): points 1, 2 and 6 are city center areas exposed to heavy vehicular traffic, and with dense populations; points 3, 5 and 7 are open to the effects of factory emissions and have low traffic density; point 4 is a low residential area out of the city atmosphere, chosen as the background point, having level traffic densities; point 8 is an area open to the emissions of the automotive industry and some other industrial production points, and has medium level vehicular traffic. The coordinates of the sampling points were determined using a Macellel Model GPS. The locations of the sampling points are Alaeddin Hill Park (coordinates, 455329E-419199N), Anit Place (4554486E-419131N), Cement Factory Garden (459249E-419927N),Selcuk University Campus (457110E-420933N), Chrome-Magnesite Factory Garden (448271E-418713N), Karatay Industry Park (456235E-419524N), Meram Region (456374E-419175N), and Sugar Factory Garden (453237E-419243N in Konya city centre.

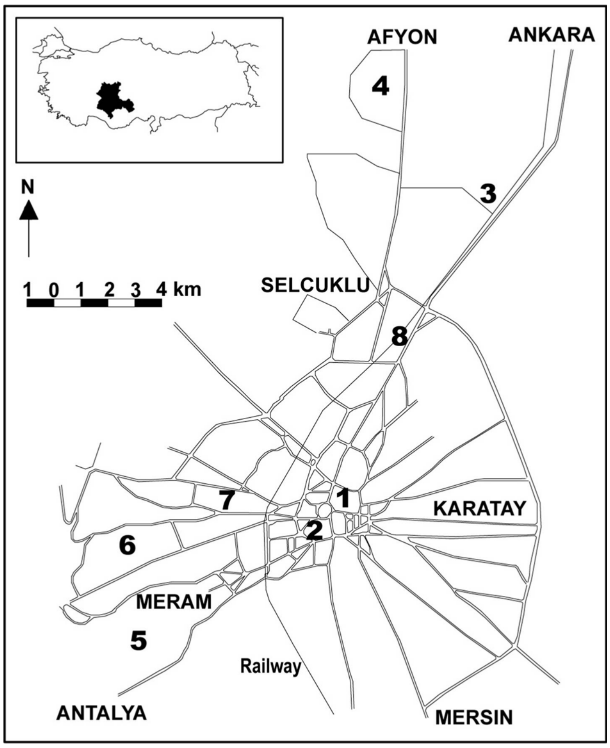

Fig.1. Locations of sampling points in Konya city centre (1. Alaeddin Hill Park, 2. Anit Place, 3. Cement Factory Garden, 4. Selcuk University Campus 5.Chrome-Magnesite Factory Garden 6.Meram Region 7. Sugar Factory Garden 8.Karatay Industry Park).

Collection and Preparation of Samples

Soil and grass samples were supplied from Konya city centre in December 2003 and April 2004. The samples were taken from the grass and soil according to the main wind direction (*i.e.* the highest wind speed). The grass samples were collected in clean cellulose bags separately and were brought to the laboratory on the same day. After removing any traces of soil and other plant materials in the laboratory, the samples were carefully washed three times with demineralized water to remove the adhering particles and were then oven-dried at 70°C for 48 h before dry weights were measured. 0.5g samples of soil or finely ground plant material were digested with concentrated HNO_3 in a microwave system (CEM). Metals in the extracts were analyzed by ICP-AES (Inductively Coupled Plasma-Atomic Emission Spectrometry, Varian-Vista model) [32] with three replicates. Used metal standards were provided from Merck, Germany.

Extractable heavy metals in the soil were determined according to the method of [33] by extraction with 0.01 M mannitol plus 0.01 M $CaCl_2$ using a sample-to-solution ratio of 1:5 and a shaking period of 16 h. Heavy metal contents were analyzed by ICP-AES. Total heavy metal content in the samples were determined using both mixed acid digestion and Na_2CO_3 fusion [34].

Statistical Analysis

The analysis of variance (ANOVA) was used for comparison sources of variation for heavy metal (Pb, Cu, Zn, Co, Cr, V, Cd and Ni) data in both grass and soil. In this research, the first source variation was the sampling point (A) and the second source variation was the sampling period (B, the years 2003 and 2004). In the analysis of variance, if F is a statistically significant aspect of any heavy metal, Duncan's multiple range tests were done on these mean data. Correlation analyses were made to investigate the relationship between heavy metal content of grass and soil. Analysis of variance, Duncan's multiple range test, and correlation were not run for cobalt contents in grass for the 2004 samples, because Co values were not detected in grass samples. Analysis of variance, Duncan's multiple range tests and correlation analysis were performed using the MSTAT-C PC package program.

Results and Discussion

Levels of heavy metals in soil and grass samples supplied from different green areas of Konya city in 2003 and 2004 are given in Tables 1 and 2, respectively. Variance analysis between grass samples and soil samples are given in Tables 3 and 4, showing the correlation coefficient between soil and grass for each heavy metal. Heavy metal content of the soil and grass samples obtained from different sampling places is shown in Fig. 2. The results of heavy metal analysis are given below with the subheadings.

Lead

The results of variance analysis showed that there were significant differences for lead between sampling periods (B) in both grass and soil samples. There were similar differences between sampling locations (A) in soil samples. However, there were none between sampling locations (A) in grass samples (Table 3). Maximum lead content was measured as 5.67 ppm in soil samples of Anit Place in the 2004 sample. The lead content of Anit Place, Karatay Industry Park and Alaeddin Hill Park was higher than that of other sampling places. Two of them were near main roads and the other was in the industrial area. Researchers [8-11, 28, 29] were notified that heavy metal content was higher in soil and plant samples collected near a main road. The addition of artificial fertilizer and pesticides causes an increase of lead levels in agricultural soil. In addition, lead comes from industrial and domestic wastewater and air pollution resulting from vehicle exhaust output and incineration of fossil fuels into the environment. The increase of lead content in the samples of 2004 compared with those of 2003 show increasing air pollution in the winter period [35].

The lead content in the grass samples was lower than those of the soil samples (Tables 1 and 2). Table 2 shows that the highest lead level was Alaeddin Hill Park sample in 2004 (3.39 ppm), followed by that of Anit Place and Sugar Factory Garden (2.97 and 2.9 ppm, respectively). The lead level in the grass samples increased between 2003 and 2004 parallel to that of the soil samples. The acceptable Pb limit level is 3 ppm for plants [36]. The reason for the high Pb content at Alaeddin Hill Park is heavy traffic in the area [11.29.37] and higher Pb content in the spring sampling period than in the previous winter sampling period shows that higher fossil fuel consumption for heating systems increased air pollution [18, 35]. There are dense residential areas around Alaeddin Hill Park in addition to high traffic levels and this reflects usage of low quality fuels. The investigations of Jones *et al*. [37] and Madojen *et al*. [11] show that people living in city centres may be poisoned by eating food containing Pb in addition to breathing contaminated air.

Copper

The results of variance analysis given in Table 3 show that there were significant differences ($p<0.01$) between sampling points (A) for soil and grass samples and also significant differences between the sampling period (B) of grass samples and also significant interaction ($p<0.01$) between sampling points and sampling periods (AxB) for soil samples. The highest Cu value as a mean of the sampling period was at Sugar Factory Garden for soil and grass samples (4.36 ppm and 10.46 ppm, respectively). The copper content in Konya Closet Basin is around 0.5-4.0 ppm [16], but the copper content of Sugar Factory Garden is higher than this value. Soil Cu content differs according to the soil type and pollution sources. Some studies have shown different values for Cu content in soil: 1.40-3.76 ppm in Madejon *et al.* [11], 6-73 ppm in Shallari *et al.* [28], 2.1-59 ppm in Çiçek and Koparal [39] and 20-118 ppm in Chen *et al.* [40]. Kabata-Pendias and Piotrowska [41] have reported that the

Table 1. Heavy metal contents (ppm) and Duncan test groups* in soil samples collected from different green areas of Konya city.

Sampling point	Year	Pb	Cu	Zn	Co	Cr	V	Cd	Ni
Alaeddin *Hill Park*	2003 2004	1.751 4.293	1.143 3.576	3.969 6.312	0.088 0.064	0.014 0.018	4.061 7.419	0.019 0.036	1.380 1.897
Mean		3.022abc	2.359bc	5.141b	0.076d	0.016ab	5.740a	0.028b	1.639c
Anit Place	2003 2004	4.035 5.665	2.859 2.584	17.283 7.327	0.102 0.120	0.016 0.020	4.299 7.039	0.044 0.044	1.746 2.167
Mean		4.850a	2.722ab	12.305a	0.111bc	0.018ab	5.669a	0.044a	1.956b
Cement Factory Garden	2003 2004	1.963 2.023	2.593 2.675	4.013 2.578	0.134 0.244	0.026 0.028	3.868 7.569	0.006 0.016	1.560 1.884
Mean		1.993bcd	2.634bc	3.296de	0.189a	0.027a	5.719a	0.011d	1.722bc
S.Univer. Campus	2003 2004	1.147 1.407	1.771 0.712	1.105 6.507	0.064 0.109	0.032 0.020	3.374 6.392	0.001 0.018	0.439 0.590
Mean		1.277cd	1.242d	3.806cd	0.086cd	0.026a	4.883b	0.010de	0.514d
Chrome-Magn.Fac.garden	2003 2004	0.776 1.252	0.576 0.708	0.752 1.044	0.068 0.078	0.010 0.022	3.546 5.988	0.002 0.008	1.158 1.454
Mean		1.014d	0.642d	0.898f	0.073d	0.016ab	4.767b	0.005e	1.306d
Meram Region	2003 2004	2.186 3.687	1.365 1.723	2.815 2.544	0.036 0.057	0.010 0.014	3.514 6.853	0.015 0.021	1.221 1.327
Mean		2.936abcd	1.544cd	2.679e	0.047e	0.012b	5.184ab	0.018c	1.274c
Sugar Factory Garden	2003 2004	2.725 2.942	3.805 4.913	4.086 5.250	0.055 0.102	0.016 0.015	3.546 5.827	0.051 0.048	2.642 2.812
Mean		2.834abcd	4.359a	4.668bc	0.078d	0.015ab	4.687b	0.049a	2.727a
Karatay Industry Park	2003 2004	2.894 3.813	4.274 2.642	2.898 3.648	0.104 0.139	0.014 0.014	3.593 6.917	0.021 0.044	1.097 1.302
Mean		3.354ab	3.458ab	3.273de	0.122b	0.014ab	5.255ab	0.032b	1.200c
Sampling point Mean	2003 2004	2.1846 3.1353	2.2983 2.4416	4.6151 4.4013	0.0814 0.1141	0.0173 0.0188	3.7251 6.7505	0.0199 0.0294	1.405 1.679
General Mean		2.6599	2.3699	4.5082	0.0978	0.0180	5.2378	0.0246	1.542

* Within columns, means followed by the same letter are not significantly different by ANOVA-protected Duncan's multiple range test ($p<0.01$).

normal content of Cu in plants ranges from 2 to 20 ppm, but in most plants the normal Cu content is in a narrower range of 4-12 ppm. Robson and Reuter [42] explained that there are different tolerance ranges for plants but a critical toxic level of coper is in the range of 20-30 ppm for most plants.

Zinc

As seen in the variance analysis between zinc contents in Table 3, there were significant differences ($p< 0.01$) for all investigated parameters (A, B, AxB) in both grass and soil samples. Mean Zn content was the highest in the soil of Anit Place (12.31 ppm) and in the grass of Cement Factory Garden (64.67 ppm) in all sampling places. Useful Zn content for plants in the soil of Konya Closet Basin is around 0.11-3.67 ppm [16], and the zinc content of sampling places in this investigation is mostly higher than this value. Zinc has limited mobility in the plant and it can be accumulate in the root system when Zn has been applied to the soil [43]. The clearest effect of Zn excess is reduction of root growth for the low tolerant plant [44]. A critical toxic level of Zn for plants is 100 ppm [45]. This toxic level was not found in the samples of this investigation.

Cobalt

The variance analysis for Co content in the soil samples showed that there were significant differences ($p<0.01$) between both sampling places and sampling periods (Table 3). A statistical test was not run for the grass samples because Co content was not measured in the 2004 grass samples. The mean Co content over the sampling periods for the Cement Factory Garden (0.19 ppm) was the highest of all the sampling places and the highest value (1.09 ppm) was in the soil of Alaeddin Hill Park in the 2003 sampling. Mostly, Co content in the soil of all the sam-

Table 2. Heavy metal contents (ppm) and Duncan test groups* in grass samples collected from different green areas of Konya city.

Sampling point	Year	Pb	Cu	Zn	Co	Cr	V	Cd	Ni
Alaeddin *Hill Park*	2003	0.9023	4.6191	23.5299	1.0904	12.0700	5.1591	0.0825	7.4636
	2004	3.3937	8.7444	49.4674	0.000	15.0568	6.1609	0.1360	7.6296
Mean		2.148	6.682abc	36.499b		13.565bcd	5.661a	0.109	7.547cd
Anit Place	2003	0.7460	9.6674	51.8771	0.2887	8.8132	1.1765	0.0904	7.6993
	2004	2.9654	9.3584	58.2144	0.000	25.6612	4.9128	0.1420	13.8347
Mean		1.852	9.513ab	55.046ab			3.045bc	0.116	10.767abc
Cement Factory Garden	2003	0.9839	5.2365	63.1116	0.4069	11.7229	5.9237	0.0845	7.9298
	2004	2.6227	6.5830	62.8990	0.000	24.9526	5.2440	0.1862	9.7963
Mean		1.803	5.910bc	64.672a		18.338abc	5.517a	0.135	8.863bcd
S.Univer. Campus	2003	1.0233	3.3680	16.2264	0.0010	16.8701	0.3797	0.1085	7.1092
	2004	1.7737	7.6121	75.1751	0.000	12.7529	7.4170	0.1824	6.0999
Mean		1.399	5.490bc	45.701ab			3.897ab	0.145	6.605cd
Chrome-Magn.Fac.garden	2003	0.8598	4.0427	27.6616	0.8408	18.5448	2.6275	0.1438	11.2019
	2004	2.4010	8.1651	57.4063	0.000	27.5066	7.0179	0.0385	15.9294
Mean		1.630	6.104abc	45.867ab		23.026a	4.823ab	0.091	13.566ab
Meram Region	2003	1.2160	3.9413	62.4242	0.2557	4.9483	1.5076	0.1199	5.3144
	2004	1.9244	6.1146	41.8819	0.000	14.5019	5.8158	0.1648	6.6053
Mean		1.570	5.028c	52.153ab		9.725d	3.662abc	0.142	5.910cd
Sugar Factory Garden	2003	0.5655	10.2320	40.8448	0.0443	23.5078	0.4850	0.1458	16.4160
	2004	2.9543	10.687	63.5207	0.000	19.7378	2.2279	0.1698	14.7669
Mean		1.816	10.459a	52.183ab		21.623ab	1.356cd	0.158	15.596a
Karatay Industry Park	2003	1.0124	8.2968	38.4326	0.0010	11.0525	0.0010	0.1494	5.6222
	2004	2.6678	8.3532	34.4389	0.000	10.6252	1.3454	0.1708	4.8868
Mean		1.840	8.325abc	36.436b		10.839cd	0.673d	0.160	5.255d
Sampling point Mean	2003	0.9137	6.1754	40.5135	0.366	13.4403	2.1575	0.1156	8.5945
	2004	2.5878	8.2022	55.3754	0.000	18.8494	5.0177	0.1488	9.9436
General Mean		1.7508	7.1890	47.9440	-	16.1448	3.5876	0.1322	9.2690

* Within columns, means followed by the same letter are not significantly different by ANOVA-protected Duncan's multiple range test ($p<0.01$).

Table 3. Summary of variance analysis for heavy metals measured from grass and soil samples collected from different green areas of Konya city.

Sources of Variation	D.F.	Importance levels of "F"							
		Grass Samples							
		Pb	Cu	Zn	Co	Cr	V	Cd	Ni
Sampling Loc. (A)	7	ns	**	**	–	**	**	ns	**
Year (B)	1	**	**	**	–	**	**	*	*
(AxB) Interaction	7	ns	ns	**	–	**	**	ns	**
Error	32								
General	47								
		Soil Samples							
Sampling Loc. (A)	7	**	**	**	**	**	**	**	**
Year (B)	1	**	ns	*	**	ns	**	**	**
(AxB) Interaction	7	ns	**	**	**	ns	ns	**	*
Error	32								
General	47								

*:%5, **:%1, ns: not significant

Table 4. Calculated correlation coefficient (r) between heavy metal levels between soil and grass samples in this investigation.

	r
Correlation between soil and grass for Pb	0.442*
Correlation between soil and grass for Cu	0.702**
Correlation between soil and grass for Zn	0.274
Correlation between soil and grass for Cr	0.367
Correlation between soil and grass for V	0.552**
Correlation between soil and grass for Cd	0.327
Correlation between soil and grass for Ni	0.688**

Significance level, *:%5, **:%1

pling places was much lower than the critical limit value (1-10 ppm; [46]). Mobility of the Co element is very slow in plants [47] and the toxic level is about 0.5 ppm [48]. The only content higher than the toxic level was in the grass samples of Alaeddin Hill Park that were measured in the 2003 sampling.

Chromium

Statistically significant differences (p<0.01) in the variance analysis for all chromium measurements of grass samples were found, but there was only a significant difference (p<0.01) between sampling places for soil samples (Table 3). The chromium contents in the soil samples were lower than other metal cations (Table 1). In the investigation area, the highest mean chromium content (0.027 ppm) for the two sampling years was in the soil samples collected from the Cement Factory Garden, but the maximum chromium value (23.03 ppm) in this study was found in grass samples collected from Chrome-Magnesite Factory Garden (Table 2). The toxic level of chromium in soil is around 2-50 ppm [46], and in comparison with this value chromium measurements were very low in the investigation area. Critical levels of Cr for the plants are 5-10 ppm [39], 0.006-18 ppm [49], and our results show that the investigation area runs a risk of Cr pollution in grass samples.

Vanadium

The highest mean value of V for the sampling periods was at the Alaeddin Hill Park for both soil and grass samples (5.74 and 5.66 ppm, respectively). Measurements of V content for the 2004 sampling were higher than for the 2003 soil and grass samples at all sampling places (Tables 1 and 2). The variance analysis of V content of soil and grass samples showed significant differences between sampling places (A) and periods (B) separately (p<0.01; Table 3). Bergmann's investigation [46] shows that a tolerable V level for plant in soil is 50 ppm and our findings are lower than this figure. On the other hand, the same investigation showed that V content in plants is between 1.32-10.01 ppm. The vanadium content in the samples of spring 2004 was higher than in those of winter 2003, probably due to usage of synthetic fertilizer ([16] explained that usage of phosphorus fertilizer increased V content of plants).

Cadmium

The variance analysis for Cd levels in the soil samples showed that there were significant differences between sampling places (A) and also sampling periods

(B), but there was only a significant difference between sampling period (B) for grass samples ($p<0.01$; Table 3). The highest mean content of Cd in all the samples was in the Sugar Factory Garden for soil (0.049 ppm) and at Karatay Industry Park for grass samples (0.16 ppm). The main source of environmental Cd pollution is the ferrous-steal industry. In addition, vehicle wheels, mineral oils and usage of waste mud may introduce cadmium into the soil and this increases Cd levels of the plants [16, 29]. The acceptable level of Cd in agriculture is

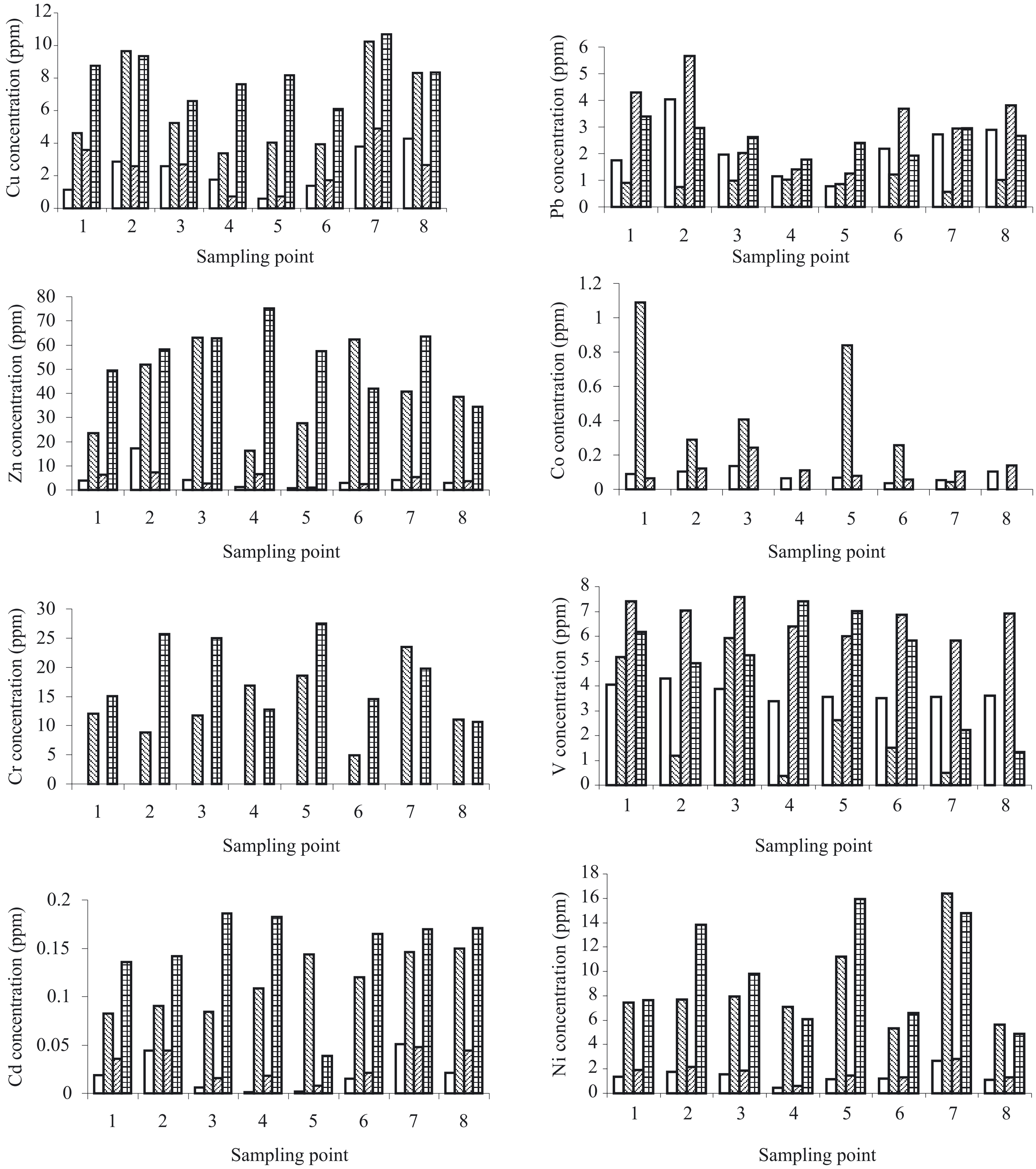

Fig.2. Pb, Cu, Zn, Co, Cr, V, Cd and Ni contents (ppm) in the soil and grass collected from 8 sampling points in Konya city centre in December 2003 and April 2004. Sampling points are 1. Alaeddin Hill Park, 2. Anit Place, 3. Cement Factory Garden, 4. Selcuk University Campus 5. Chrome-Magnesite Factory Garden, 6. Meram Region, 7. Sugar Factory Garden, 8. Karatay Industry Park. Symbols in the figure: □ 2004 sample of soil, ▨ 2003 sample of grass, ▧; 2003 sample of soil, ▦; 2004 sample of grass.

around 3 ppm and generally is lower than 0.1 ppm in the soil [39, 50]. Our findings for Cd in the soil samples showed lower levels and there is no risk from cadmium in the investigation area. Accumulation of Cd in the plants increases with increasing salinity in the soil [51]. The soil of the Konya region has higher pH values and grass samples have higher Cd content than critical levels for plants (0.05 ppm; [52]). The results showed that there was cadmium pollution in plants.

Nickel

Studies in different countries show nickel contents in soil on a wide scale from 0.2 to 450 ppm. Nickel toxicity is generally seen in soil irrigated with wastewater. Nickel is absorbed easily and rapidly by plants [16]. The critical level for Ni in soil is around 2.0-50 ppm from the study of [11, 16, 28, 46]. According to this study, there is no critical nickel pollution in the investigation area. The highest Ni content was measured in the soil and grass samples of Sugar Factory Garden (2.73-15.60 ppm, respectively). There were significant differences between sampling places for Ni content ($p<0.01$; Table 3).

Relationships Between Heavy Metals in Soil and Grass

Correlation coefficients between soil and grass samples, as mean heavy metal content of different sampling periods and places, were calculated for each metal separately (Table 4). As seen in Table 4, there are positive correlations between soil and grass for all metal content in the investigated region. These relations were not statically significant for Zn, Cr and Cd, but were significant for Pb, Cu, V and Ni ($r= 0.442^{*}$, $r= 0.702^{**}$, $r= 0.552^{**}$ and $r= 0.688^{**}$ respectively). Results of some earlier investigations [11, 23, 53] may support our findings. Some of the metals investigated in this study are at the same time trace elements for the plants. Positive relationships for metal content between soil and plants are expected results, because plants take nutritional elements from the soil via their roots [16].

Conclusion

One of the main components of air pollution in Konya city center is heavy metal pollution. Heavy metals are generally released into the air from industry, the use of fossil fuels for heating systems and vehicle exhausts. The topographic layout of the polluted region, dominant wind direction and suitability of the city settlement plan affects air pollution. People living in the city centre might be affected by heavy metals from air pollution and also from eating contaminated vegetables. In this research, the soil and plant samples collected from green places in the study area were investigated and the level of pollution was determined. Contents of analyzed metals in the soil as the mean of sampling points and sampling periods was, in order from high to low, V, Zn, Pb, Cu, Ni, Co, Cd and Cr, and in the grass samples Zn, Cr, Ni, Cu, V, Pb, Co, and Cd (from high to low). According to the mean values of the two years in the samples of grass and soil, the highest content of Cu and Cr was obtained from Sugar Factory Garden and Chrome-Magnesite Factory Garden, respectively. Cd was generally higher in plants of most sampling places and Pb passed over the critical level at Alaeddin Hill Park, Anit Place and Karatay Industry Park. Some of the heavy metals were at a significant pollution level in the heavy traffic and settlement areas (Alaeddin Hill Park and Anit Place), around the factories (Cement Factory Garden, Chrome-Magnesite Factory Garden and Sugar Factory Garden) and in the industrial region (Karatay Industry Park), but was not the case in the low traffic and settlement areas (Campus and Meram Region).

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