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Determination of Heavy Metal Pollution at Mevlana Park (Konya-Turkey) by Analysis of Soil, Grass and Cedar Tree Needles

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In this study, soil, grass (mostly *Lolium* sp.) and cedar tree (*Cedrus libani*) needles were used for determination of heavy metal pollution level at Mevlana Park in Konya city centre. Heavy metal levels *i.e.*, Pb, Cu, Zn, Co, Cr, V, Cd, Ni and As were investigated in all the samples of soil, grass and tree needles during 2003 and 2004 years. According to the results of this study, there were statistically significant differences for heavy metals contents in the cedar tree needles between the years 2003 and 2004 except, Cd and As. Similarly, measurement for heavy metals contents in the samples of grass and soil collected in 2003-2004 years were also statistically significant different except Cr and Ni. Some of the metals as Pb, Cu, Cr, V and Cd were over the limits values, but Zn, Co, Ni and As were not over the critical levels. Only Cu content was higher in the soil samples, on the other hand, Cu, Cr and Cd content in the grass samples and Pb, V and Cd content in the cedar tree leaves were higher than critical levels for human health.

Key Words: Nitrite, Pollution, Adsorption, Removal, Wood, Sawdust, Water.

INTRODUCTION

Mevlâna Museum housed in the first tekke (lodge) of the Devrish sect and is considered to be a holy place because it contains the tomb of Mevlâna Celaladdin Rumi. The Museum originally covered an area of 6,500 m^2 together with its garden, with the section expropriated later and designed as rose garden, it has today reached a size[1] of 18,000 m^2. Pollution of the environment with toxic metals has increased dramatically since the onset of the industrial revolution[2]. Soil pollution with heavy metals, such as cadmium, lead, chromium, copper *etc.* is a problem of concern. Although heavy metal

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are naturally present in soils, contamination comes from local sources, mostly industry (mainly non-ferrous industries, but also power plants, iron and steel and chemical industries), agriculture (irrigation with polluted waters, swage sludge and fertilizer, especially phosphates, contaminated manure, sewage sludge and pesticide containing heavy metals), waste incineration, combustion of the fossil fuels and road traffic. Long-range transport of atmospheric pollutants adds to the metals to the natural area[3]. In recent years, it has been shown that lead levels in soil and vegetation has increased considerably due to traffic pollution, *etc.*, usage of leaded petrol and exhaust combustion[4,5]. The problem rises as daily traffic increases[6]. Recently, a report was made which confirmed that the main source of air pollution in city areas of Turkey was due to the amount of traffic on the road using leaded petrol[7].

The emission of toxic substances in the environment has been spread from industriallized countries. However, many sites around the world remain contaminated, representing a risk to humans and other organisms. Heavy metals are among the pollutants that need to be removed from such contaminated sites. Several heavy metals such as, Pb, Co, Cd, Cu and Cr are considered hazardous waste metals that can accumulate in the human body. It has been stated for example, that Cd has a half-life of 10 years once in the human body[8]. Additionally, some species of Cd, Cr and Cu have been associated with health effects ranging from dermatitis to various types of cancer[9]. Time-series analyses, conducted in many industrial towns, have consistently shown that short-term changes in air pollution levels are associated with changes in daily death rates[10]. Heavy metals pose serious environmental risks and therefore, its effect has been examined extensively.

Soils around the heavy industrialized region were contaminated with toxic metals. While soil clean up techniques such as isolation and containment, mechanical separation, chemical treatment or soil washing have proven to be effective in small areas[11], they require special equipment and intensive laboratory. Furthermore, these methodologies are not only costly, but they also cause soil disturbances and are not readily accepted by communities. Phytoremediation, the use of plants to restore polluted sites, has recently become alternative to traditional methodologies[12]. It has been established that certain wild and crop plant species have the ability to accumulate elevated amounts of toxic heavy metals[13,14].

There are limited studies on the environmental pollution by the heavy metals in Turkey. Investigation of Kardemir and Toker[15] showed that Pb accumulation in the grass growing near the main road junction in Ankara (Turkey) was increase for 6 month experimental period. Cinar and Elik[16] analyzed samples collected from 7 different sampling point in Sivas city (Turkey) during June and July months to show environmental pollution effect on heavy metal levels in plant materials indicated that concentration heavy metals were as seen following; Zn, 12.4, Pb 6.8, Ni 6.8, Cu 5.5 and Cd 0.2 μg g^{-1} plant material. Similar investigation in Erzurum by Yilmaz and Zengin[17] showed that Pb and Cu are important environmental problem in winter period but there was not any problem for Zn.

In this study, effect of heavy traffic, industry and fossil fuel usage in residential at Mevlana Museum Park in Konya city centre on the environmental pollution was investigated with heavy metal content measurements of soil, grass and tree samples for two year experimental period and the effect of measurement results on human health was discussed.

EXPERIMENTAL

Study area, Konya located in the central Turkey. Konya has central three districts: Selcuklu, Karatay and Meram. City of Konya is located between 36º41′ and 39º16′ east meridians and 31°14′ and 34º26′ north parallels. The average height of the city from the sea level is 1024 meters. The annual average of the total precipitation is 320 mm in a year. Experimental materials are grass species (mostly *Lolium* sp.) belongs to *Gramineae* family, Cedar tree (*Cedrus libani*) leaves and soil samples collected from Mevlâna Park. Cedar tree is the most dominant tree species at the green area in the Konya city. For this reason, needles of the Cedar tree were used in this study. Mevlâna Park is located in Karatay district and occupied 18,000 m^2 total area with Mevlâna Museum. There is heavy traffic flow around this green area.

Collection and preparation of the samples: Soil grass and Cedar tree samples were supplied from the Mevlâna Park in December 2003 and April 2004. The needle materials (*Cedrus libani*) samples were collected from the two type of trees which they are young (10-15 years old) and (20-25 years old). Each soil and grass samples were prepared mixing 10 samples collected from the different places of the Mevlâna Park. Plant samples (grass and needles) were collected in the clean cellulose bags separately and were brought to laboratory in the same day. After removing any traces of soil in the laboratory, the samples were carefully washed three times with distilled water to remove adhering particles and were then oven-dried at 70 ºC for 48 h before dry weights were measured. Samples (0.5 g) finely ground plant materials were digested with conc. HNO_3 in a microwave system (CEM). Metals in the extracts were analyzed by Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES), Varian-Vista model) with three replicates[18].

Extractable heavy metals in the soil were determined according to the Cartwight *et al.*[19] by extraction with 0.01 M mannitiol plus 0.01 M $CaCl_2$ using a soil: solution ratio and analyzed by ICP-AES. Total heavy metal contents in the soil were determined by both mixed acid digestion and Na_2CO_3 fusion[20].

Statistical analysis: Each heavy metal result obtained from cedar tree needles was subjected to the variance analysis (ANOVA). In this analysis, first factor was sampling years (2003 and 2004) and second factor was plant ages (yang and old trees). Separately variance analysis run for each heavy metal (Pb, Cu, Zn, Co, Cr, V, Cd, Ni, As) as three replicates according to factorial experimental design, there was no significant difference between years and sample ages ($p < 0.05$, $p < 0.01$). Differences between years were determined with separate 'Paired t' test for each metal in grass and soil samples. Analysis of variance and 'Paired-t' tests were performed using MSTAT-CPC. package program.

RESULTS AND DISCUSSION

In this study, environmental pollution dimension was investigated at Mevlana Museum Park in Konya city with the results of heavy metal contents of Cedar tree needles for years and tree ages and soil and grass samples for the years.

Lead: There were important differences between the mean of years from the statistical analyses for the Pb data obtained in this study. These differences were significant for cedar tree needles samples ($p < 0.01$) and for soil and grass samples ($p < 0.05$) (Table-1). Lead contents in the samples of cedar tree needles and grass collected in 2004 (spring) were higher than samples collected in 2003 (autumn). Lead levels in soil samples were higher than plant samples (Fig. 1). Exhaust gasses from the heavy traffic around the Mevlana Museum Park together usage pesticide and other artificial chemicals may be increased to the accumulation of Pb in the soil[21]. In the same way, the close relationship between lead concentrations and traffic intensity has been demonstrated in detail by many scientists[22,23]. Acceptable Pb limit levels were 3 ppm for plants[24], 15 ppm for soils[25] and present findings in the cedar tree needles in 2004 year sampling was higher than limit values. Although traffic was very heavy around the Mevlana Park and the population were also very high around the sampling place. Jones *et al.*[26] showed people living in the city centre were poisoned with lead respiration from ambient air and were also poisoned with lead contaminated food in the food chain.

Copper: Table-1 shows that there were significant differences ($p < 0.01$) for copper content of cedar needles samples between both sampling years and sample olds and also between sampling years of soil and grass samples. Copper content in the cedar tree needles was lower than critical levels for both 2003 and 2004 sampling years, but it was higher value in soil and grass samples especially in 2003 sampling (Fig. 1). Average copper contents of Konya Closed Basin soils[27] are 0.5-4.0 ppm. Markert[28] and Kabata-Pendias and Piotrowska[29] indicated that normal Cu content in the plants is about 10 and 4-12 ppm, respectively. According to Robson and Reuter[30] for toxic limit of copper for the plans is 20-30 ppm and there are different tolerances levels between the plants to copper concentrations.

TABLE-1
SUMMARY OF VARIANCE ANALYSES AND PAIRED-t TEST RESULTS FOR THE SAMPLES COLLECTED FROM THE MEVLANA PARK IN KONYA CITY CENTRE

Variance sources	DF	Significance degree of "F" for Cedar tree needles (ANOVA)								
		Pb	Cu	Zn	Co	Cr	V	Cd	Ni	As
Year (A)	1	**	**	**	**	**	**	ns	**	ns
Ages (B)	1	ns	**	ns	ns	*	ns	ns	**	ns
(A × B) Interaction	1	ns	**	*	ns	ns	**	ns	ns	ns
Error	8									
General	11									
Paired-t test for grass samples										
Years		*	**	*	*	ns	*	*	ns	*
Paired-t test for soil samples										
Years		*	**	*	*	ns	**	*	ns	**

*5 %, **1 %, ns = not significant, DF = Degree of freedom.

Zinc: According to the results of statistical analysis of Zn contents, there were significant divergences between the years for cedar tree needles ($p < 0.01$) and soils ($p < 0.05$; Table-1). Zinc is an important micro-nutrient element for the plants and its critical toxic levels are over the 100 ppm[31]. Average level of Zn in the soil is around 3-90 ppm and tolerable level[32] is 300 ppm. Zinc measurements were lower than the toxic level in the all samples.

Cobalt: As the results of measured cobalt content in cedar tree needles, there were significant differences ($p < 0.01$) between the sampling years, but it was 5 % level for soil and grass samples ($p < 0.05$; Table-1). Because of the critical toxic Co levels in the soils are between 1-10 ppm[32], there is no risk for Co content in the research area. Cobalt movement in the plant is very difficult[33]. Average level of Co in the plants is 0.2 ppm[28] and toxic limit level is 0.5 ppm[34]. In comparison these limits, content of Co in the plant materials was lover than toxic concentration.

Chromium: From the variance analyses of results of Cr measurements in the cedar tree needles, there were significant differences between sampling periods ($p < 0.01$) and sample ages ($p < 0.05$), but similar significant

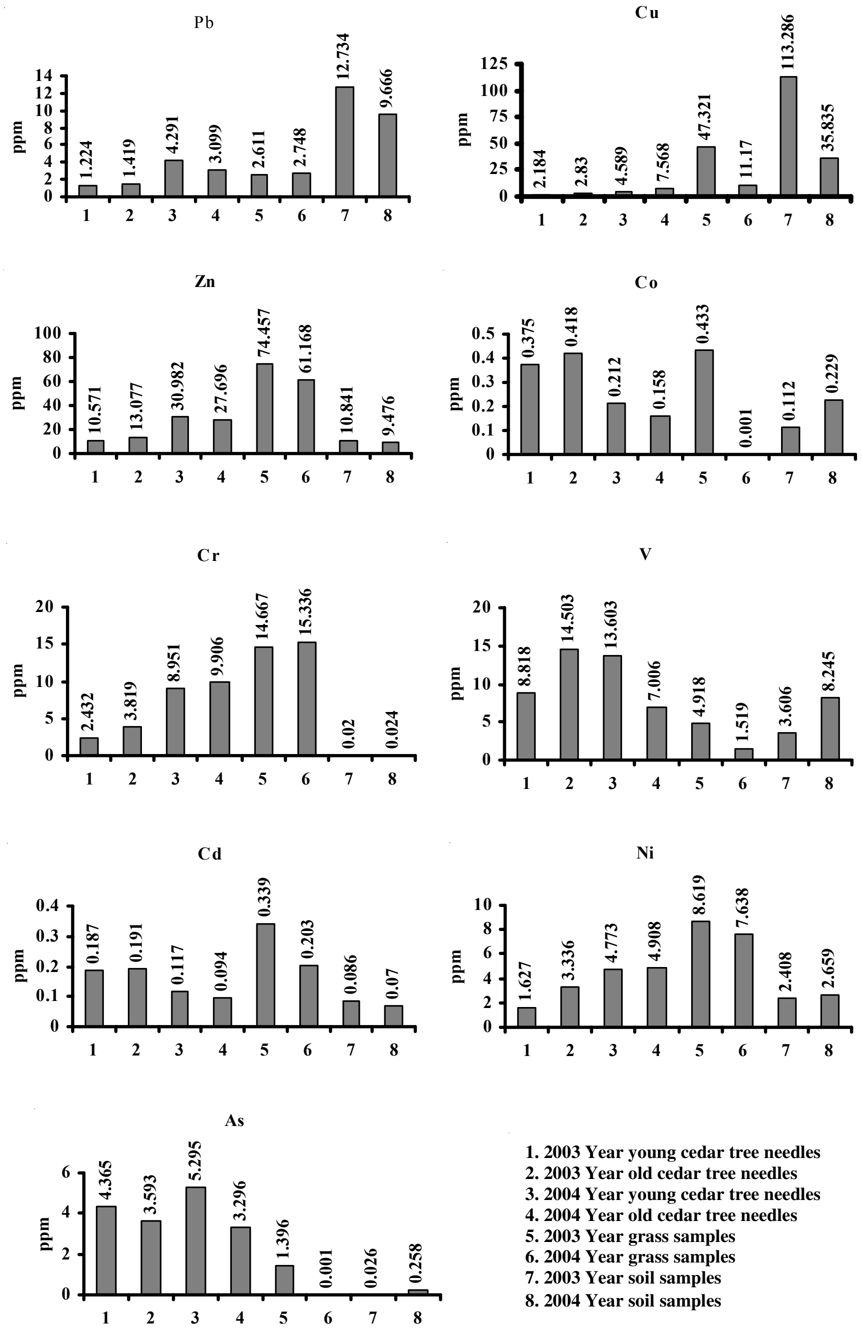

Fig. 1. Pb, Cu, Zn, Co, Cr, V, Cd, Ni and As contents (ppm) according to years (2003 and 2004) and materials (cedar tree needles, grass and soil)

differences were not found at soil and grass samples for Cr measurements (Table-1). Chromium levels in the sampling place Mevlana Museum Park soils were lower than general Cr levels (2-50 ppm) in the natural soils[32]. However, Cr content in the cedar tree needles collected in 2004 and grass needles collected 2003 and 2004 years were closed the critical levels (5-10 ppm) for plant[35], especially there is toxicity risk for grass (Fig. 1).

Vanadium: Statistical analyses for vanadium contents showed that significant differences were found for all sample types. These were cedar tree needles samples ($p < 0.01$), grass samples ($p < 0.05$) and soil samples ($p < 0.01$; Table-1). Study of Bergmann[32] shows that tolerable level of V for plants is 50 ppm. The present findings in the study area were lower than these values (Fig. 1). Bergmann[32] has also described that, normal values of V content of the plans are between 1.32-10.01 ppm. Vanadium content of the some cedar tree needles were higher than normal levels for plant, these probably may resulted from usage of artificial fertilizer in the area.

Cadmium: For the variance analyses with the results of Cd in the cedar tree needles, all the subjects were not significant ($p > 0.05$). But results of 'Paired-t' test with grass and soil samples V contents showed that there were significant difference between the years ($p < 0.05$ and $p < 0.01$, respectively) (Table-1). Generally Cd content in the soils was between 0.1-1.0 ppm levels[32,36]. Results of this study were lower than the critical level and there is no Cd metal pollution in the soil of study area (Fig. 1). Increasing soil salinity and lower pH increase Cd accumulation in the plants[37]. Mevlana Museum Park soil pH was higher than 7, for this reason, Cd level in the cedar tree needles and grass samples were higher than critical level (> 0.05 ppm) for plant[38].

Nickel: Statistical analyses with results of cedar tree needles Ni contents showed that all subjects were not significant ($p > 0.05$), but there were significant difference ($p < 0.05$) between the years at the soil and grass Ni contents (Table-1). Bergmann[32] has put forwarded that Ni amount in the soil changes between 2 to 50 ppm. When the Ni content of the soil exceeded to 3-5 ppm, plant may be affected from Ni content of soil, because, the plants takes the Ni from the soil easily and quickly. Nickel content of the plants is normally 1.5 ppm and critical toxic level was over 10 ppm, so this point, there is no risk for the Ni content in the study area.

Arsenic: The results of the statistic analyses with As measurements of cedar tree needles show that there was not significant differences in comparison parameter. But significant differences were found between the sampling years for grass ($p < 0.05$) and soil ($p < 0.01$) samples. There were differences worldwide soils as contents, normal concentration were accepted[34] between 4 to 9 ppm. Average plant As content was accepted around 0.01-1.0 ppm and over 3-10 ppm was accepted toxic concentration according to plant types[39]. However, the match as content in the cedar tree needles was found, it was not exceeded to the toxic level for plant in this study (Fig. 1).

Conclusion

Heavy metal pollution which is one of the most important components in pollution sources around the Mevlana Museum Park in the city centre of Konya measured for two years sampling period. The authors tried to determine heavy metals and to put forward changes by the years in recent investigation. Heavy metals were released generally to atmosphere by the industrial plants, usage of fossil fuels for heating systems and traffic vehicles. Topographic structure, main wind direction and city settlement plan at the polluted region affected to the city pollution dimension. Specially, people living in the city centre may be poisoned with respiration to polluted air with heavy metal pollution.

In this study, heavy metal content in the soil, grass and tree leaves samples collected from the green area of Mevlana Museum Park which is visited by the thousands tourist from different countries and religions were determined for two years sampling period. As a result, Pb in the cedar tree needles in 2004 year sampling, Cu in the soil and grass samples in 2003 years, Cr in grass for both sampling years, V in cedar tree needles for sampling years, Cd in the grass and cedar tree needles for two sampling years were over the critical toxic level. For Zn, Co, Ni and As, critical level were not passed two sampling period.

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