BIOMEDICAL AND ENVIRONMENTAL SCIENCES **19**, 254-261 (2006)

Trace Metal Pollution From Traffic in Denizli-Turkey During Dry Season[1]

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Objective To determine the metal contents of date palm (*Pheonix dactylifera*) samples in dry season from Denizli-Turkey for investigation of heavy metal-polluted traffic. **Method** The levels of iron, copper, zinc, lead, cadmium, nickel, chromium, and manganese ions in the leaves of thirty five date palm (*Pheonix dactylifera*) samples collected from various levels of traffic in the streets of Denizli-Turkey were determined by graphite furnace or flame atomic absorption spectrometry. The wet, dry, and microwave digestion procedures for the date palm (*Pheonix dactylifera*) leaves were compared. The accuracy of the digestion procedures was checked using a standard reference material (IAEA-336 Lichen, SRM). **Results** Microwave digestion procedure for the leaves was preferred because it was more proper with respect to both time and recovery than dry and wet digestion. The levels of the heavy metal ions investigated were the highest on the samples from high traffic level. Also correlations between metal levels and traffic volume for all the metals were investigated. **Conclusion** In the light of our findings, the date palm (*Phoenix dactylifera*) leaves are suitable as a biomonitor for atmospheric heavy metal-polluted traffic. Significant correlations can be obtained between traffic levels and heavy metal concentrations.

Key words: *Phoenix dactylifera*; Microwave digestion; Atomic absorption spectrometry; Denizli; Turkey

INTRODUCTION

Transition metals are required by plants. Copper, manganese, and zinc are plant micronutrients. These elements are essential at low concentrations, but are toxic at higher levels[1-4]. Lead, cadmium, and chromium are not natural substances in plant nutrition. In case of Cd and Pb, toxicity is induced by mimicking of lighter essential elements in uptake and biochemical behavior[5-8]. Lead is used in accumulators, to produce tetraethyl lead, guns, solders, and X-ray equipment, among other uses. Lead inhibits biosynthesis and affects the kidneys, brain cells and liver membrane permeability, reducing some of their functions. It accumulates in the body and promotes disturbances such as nausea, vomiting, diarrhea, sweating and, in some cases, convulsions, coma and death[9]. Lead is a well documented metal toxicant, exposure to it leads to many fatal diseases, including the dysfunction of renal blood and neurological systems[10-12]. Copper is used in the electrical industries, household, metallic blends, and pigments. Copper is an essential element for enzymes, but over a healthy limit it accumulates in the liver, causing dizziness, vomiting, diarrhea, transpiration[9].

As a result, the biological monitoring of toxic and essential metals in biological materials can be an important approach for the study of influence of environmental conditions of the human body[13-15]. The main sources of the toxic and essential heavy metals in the environment are metallurgy industries, combustion of coal and high traffic density.

Monitoring trace elements to investigate metal pollution sources is continuously performed for the cities around world[16-17]. Date Palm (*Pheonix dactylifera*) is an important indicator for the investigation of trace heavy metal ions[18]. Various works have been performed for the determination of trace metal pollution from heavy metals after digestion of the date palm samples. Al-Shayeb[18] reported that the ability of *Phoenix dactylifera* leaflets to retain heavy metal (Pb, Zn, Cu, Cr, Ni, and Li) pollutants is compared with the leaves of *Nerium*

[1]This work was financially supported by the Units of the Scientific Research Projects of Gaziosmanpasa University, Pamukkale University and Erciyes University.
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0895-3988/2006
CN 11-2816/Q

oleander. Date palm (*Phoenix dactylifera*) has been tested as a possible biomonitor of heavy metal pollution at Antalya, Turkey[19].

Various instrumental methods such as inductively coupled plasma-atomic emission spectrometry (ICP-AES), inductively coupled plasma-mass spectrometry (ICP-MS), total reflection x-ray reflection fluorescence spectrometry (TXRF), isotope dilution mass spectrometry (IDMS), neutron activation analysis (NAA), flame or graphite furnace atomic absorption spectrometry (FAAS or GFAAS) have been used as a determination step for trace heavy metal ions. The reliability of trace heavy metal determination in its complex matrices mainly depends on the dissolution process used. Both the wet and dry ashing procedures are slow and time consuming. In recent years, microwave digestion procedures in closed vessels have been developed as a rapid and reproducible sample preparation method for a great variety of complex matrices[20-22].

Denizli lies on the main roads that connect the regions of Aegean, Central Anatolia, and Mediterranean Regions of Turkey. Its latitudes are 28.30 and 29.30 whilst the longitudes are 37.12 and 38.12. The City lies 354 m above the sea level. The highest mountain of the Province, Mount Honaz at 2571, is also the highest mountain in Western Anatolia. Though located in Aegean Region, Denizli is not totally affected by the Aegean climate. Instead, because it is placed on the transition point between coast line and the inner parts, Denizli to a certain extent displays a terrestrial climate. Denizli Province is open to the winds coming from the sea because of the perpendicular extension of the mountains. Winter months are warm and rainy. Denizli is primarily an agricultural market city with some light industry, particularly cotton fabric production. Denizli, according to the census of the year 2000, has a total population of 850 000. Yearly population growth rate of the total population is 12.40%. The City of Denizli has a population increase rate of 20.43 by itself.

In the present work, the levels of some trace metals in the leaves of date Palm (*Pheonix dactylifera*) from Denizli-Turkey were determined by atomic absorption spectrometry. The correlations between metal concentrations in the samples and traffic levels were also investigated.

MATERIALS AND METHODS

Reagents

All reagents were of analytical grade unless otherwise stated. Double deionised water (Milli-Q Millipore 18.2 MΩ/cm resistivity) was used for all dilutions. HNO_3 and H_2O_2 were of suprapure quality (E. Merck, Darmstadt). All the plastic and glasswares were cleaned by soaking in 10% diluted HNO_3 and rinsed with distilled water prior to use. The element standard solutions used for calibration were prepared by diluting stock solutions of 1000 mg/L of each element from Sigma. The standard reference material used in the experimental studies was a Lichen standard reference material (IAEA-336 Lichen).

Apparatus

A Perkin Elmer AAnalyst 700 atomic absorption spectrometer equipped with a HGA graphite furnace and a deuterium background corrector was used. For flame measurements, a 10 cm long slot-burner head, a lamp and an air-acetylene flame were used. For graphite furnace measurements, argon was used as inert gas. The operating parameters for working elements were set as recommended by the manufacturer (Table 1). Pyrolytic-coated graphite tubes (Perkin Elmer part no. B3 001264) with a platform were used. Samples were injected into the graphite furnace using Perkin Elmer AS-800 autosampler. The atomic absorption signal was measured as a peak height mode against an analytical curve.

Sampling

The leaves of date palm (*Pheonix dactylifera*) were collected in various stations from May 2003 to July 2003 in the dry season of the Denizli City. Each sampling point is given in Fig. 1. Total number of the samples was 37. Sampling sites were divided into four groups as C: control samples, A: low traffic volume, O: moderate traffic volume, Y: high traffic volume.

In each sampling site, leaves were detached from the date palms. Surface dust from leaves was removed by first washing the freshly collected leaves with running distilled water. Leaves were then dried overnight at 110℃ and ground with a blender to a size less than 1.0 mm. The crushed dried samples were stored in a labelled plastic bag for further analyses.

Digestion Procedures

Three different types of digestion procedures were applied to digestion of the leaves of the date palm (*Pheonix dactylifera*) samples: dry, wet, and microwave digestions. The procedures were given below.

a- Dry Ashing

One gram of date palm sample was placed into a high form porcelain crucible. The furnace temperature

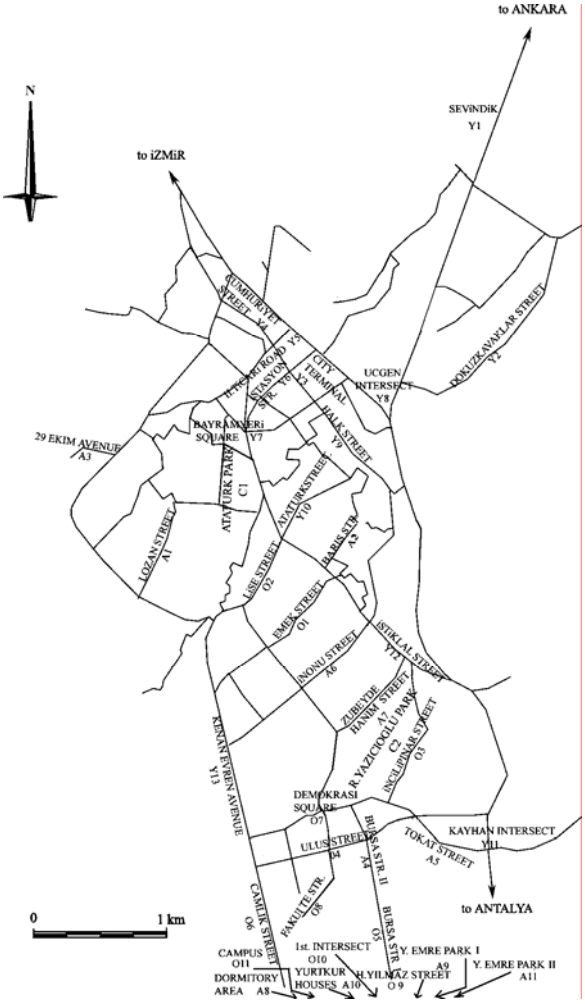

FIG. 1. The sample locations in the map of Denizli.

was slowly increased from room temperature to 450℃ in one hour. The samples were ashed for about 8 h until a white or grey ash residue was obtained. The residue was dissolved in 5 mL of HNO_3 (25% v/v) and the mixture, when necessary, was heated slowly to dissolve the residue. The solution was transferred to 10 mL volumetric flask and made up to volume. A blank digest was also carried out in the same way.

b- Wet Ashing

Wet digestion of palm samples was performed using an oxi-acidic mixture of HNO_3 : H_2O_2 (2:1) (12 mL for 1.0 g sample). This mixture was heated until dryness for 4 h and brought to a volume of 10 mL with deionized water. Blank digestions were also carried out in the same way.

c- Microwave Digestion

One gram of sample was digested with 6 mL of HNO_3 (65%) and 2 mL of H_2O_2 (30%) in microwave digestion system and diluted to 10 mL with deionized water. A blank digest was carried out in the same way. All sample solutions were clear. Digestion conditions for microwave system were applied as 2 min for 250 W, 2 min for 0 W, 6 min for 250 W, 5 min for 400 W, 8 min for 550 W, vent: 8 min, respectively.

Analytical Procedure

Detection limit was defined as the concentration corresponding to three times the standard deviation of ten blanks. Detection limit values of elements as milligram per liter in flame AAS were found to be 0.004 for Cu, 0.005 for Zn, 0.008 for Fe. Pb, Cd, Cr, Ni, and Mn were below detection limit of flame AAS. These elements were determined using graphite furnace AAS by an autosampler. During analyses, internal argon flow rate through the graphite tube was 250 mL/min; gas flow was interrupted during atomization. Sample volume, ramp and hold times for the drying, ashing, atomization and cleaning temperatures were optimized before analysis to obtain maximum absorbance and minimum background. Matrix modifiers were added 200 µg $NH_4H_2PO_4$ for Pb, 15 µg Pd + 10 µg Mg $(NO_3)_2$ for Cd and 50 µg $Mg(NO_3)_2$ for Ni, Mn, and Cr. Most of the matrix was removed before the atomization step and less interference occurred during atomization. Each graphite furnace atomic absorption spectroscopic analysis called for 20 µL of solution and 5-10 µL of the matrix modifier was added if necessary. The signals were measured as peak height. The absolute sensitivity was defined by the mass of an element, which gave a peak absorbance of 0.0044. It was 0.5 pg for Cd, 3.0 pg for Cr, 13 pg for Ni, 2.0 pg for Mn and 10 pg for Pb.

Statistical Analysis

The whole data were subjected to a statistical analysis and correlation matrices were produced to examine the inter-relationships between the investigated heavy metal concentrations of the samples. Student's *t*-test was employed to estimate the significance of values.

RESULTS

In the beginning of the work, the procedures were checked by recovery studies. The recovery values were nearly quantitative for all digestion methods. The relative standard deviations were less than 10% for all investigated elements. T-test was used in this study (P<0.05). The performances of the three digestion procedure were compared. For this

purpose, a sample (A2) was digested by all three methods. The results are given in Table 2.

In order to compare the results found by dry, wet, and microwave digestion procedures, IAEA-336 Lichen-reference standard was digested with three procedures. The results of this study are given in Table 3. The recovery values of the investigated metal ions after the dry, wet, and microwave digestions for IAEA-336 Lichen were quantitative (>95%).

The comparison of dry, wet, and microwave digestion methods showed no statistically significant differences in results (Tables 2 and 3). Therefore, the microwave digestion procedure was chosen for the samples because of more accurate with respect to both time and recovery than dry and wet digestion. The standard deviations of the dry and wet digestion methods were considerably higher than those of the microwave digestion method.

Lead, cadmium, iron, copper, manganese, zinc, chromium and nickel were chosen as representative trace metals whose levels in the environment represent a reliable index of environmental pollution. Heavy metal levels in the analysed date palm samples are given in Tables 4-6. The mean level of the investigated metal ions in control, low traffic, moderate, and high traffic is depicted in Fig. 2. All heavy metals had the highest levels at the high traffic level. Also the investigated metals had the lowest levels at low traffic level except for chromium, manganese and cadmium. Also the mean levels of the investigated ions in the two control samples collected from two parks which have no traffic are depicted in Fig. 2. The concentrations of the analytes in all analyzed samples were generally higher than those in the control samples.

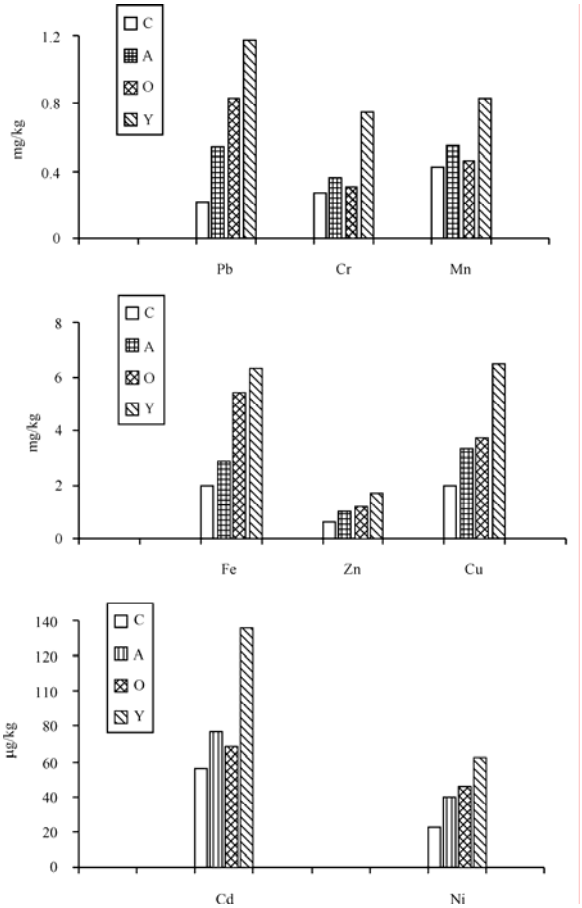

FIG. 2. The levels of investigated metal ions as a function of the traffic level (C: Control samples, A: Low level traffic, O: Moderate traffic, Y: High level traffic).

DISCUSSION

The main source of lead from traffic is probably automobile emissions. The lead contents of the environmental samples from heavy traffic and car parks may be due to the exhaust of the old motor vehicles because of the usage of unleaded petrol on the automobiles in Turkey. But these low concentration values of lead in regard to urban cities show that lead accumulation is not strongly influenced by traffic. The lead concentration in the date palm samples was increased with increasing traffic volume. The highest lead concentration was found in samples collected from high traffic volume (Halk Street) as 1.98 µg/g. The lowest lead concentration was found in samples collected from low traffic volume (Lozan Street) as 0.22 µg/g. The mean lead concentrations in samples collected from low, moderate, and high traffic volumes were 0.54, 0.83, and 1.17 µg/g, respectively. The mean lead concentration range in date palm (*Pheonix dactylifera*) samples has been reported as 1.99-5.06 µg/g[23]. Aksoy and Ozturk[19] reported that the lead range of date palm (*Pheonix dactylifera*) from Antalya-Turkey is 2.18-24.37 µg/g.

Cadmium is released as combustion products in the accumulators of motor vehicles or in carburetors. Cadmium concentration was found in the range of 43.2-188.1 µg/kg in the samples. The mean cadmium concentration in low and high traffic volumes was 77.2 and 136.3 µg/kg, respectively. Mean level of cadmium in date palm samples has been reported as 603 µg/kg by Aksoy and Ozturk[19]. The average cadmium concentration in date palm (*Pheonix dactylifera*) samples has been reported as 50-125 µg/kg[24].

The mean copper levels in date palm samples from low and high traffic volumes were 3.3 µg/g (number of vehicle/h=158) and 6.5 µg/g (Number of vehicle/h=575). Copper from traffic comes from

corrosion of metallic parts of cars. The range of copper concentration in date palm samples from Antalya-Turkey is 3.04-5.64 µg/kg [19].

As can be seen in Tables 4-6, the zinc concentration was in the range of 0.6-3.5 µg/g in low traffic volume (Bursa Street II) and high traffic volume (Halk Street), respectively. The level of zinc in *Pheonix dactylifera* from Antalya-Turkey was 7.07-14.18 µg/g[19].

The main source of manganese from the traffic has been reported as tyre wear. Manganese contents of the samples were in the range of 0.35 µg/g (Number of vehicle/h=252) and 0.96 µg/g (Number of vehicle/h=516). The minimum and maximum iron concentrations in low and high traffic volumes were 1.6 and 9.4 µg/g, respectively (Tables 4-6).

Chromium is an essential nutrient for plant and animal metabolism. Chromium is a major water pollutant, usually as a result of some industrial pollutions including tanning factories, steel works, industrial electroplating, wood preservation *etc.* and artificial fertilizers. At high levels it can cause several disorders, including lung cancer. Chromium levels in the samples varied from 0.18 and 0.99 µg/g. Our values are in agreement with those reported in the literature[25].

Nickel is also an important pollutant from traffic and industry. The minimum and maximum nickel levels are 22.4 µg/kg (Number of vehicle/h=138) and 83.2 µg/kg (Number of vehicle/h=480). The mean nickel concentrations in date palm samples from low, moderate and high traffic volumes were 39.4 µg/kg, 45.5 µg/kg, and 62.4 µg/kg.

A linear regression correlation test was performed to investigate the correlations between vehicle number and metal concentrations in leaves of date palm (*Pheonix dactylifera*) samples from Denizli-Turkey. The values of correlation coefficients are given in Table 7. The correlation between metals and traffic levels is highly significant according to the data given (correlation coefficient > ± 0.50) by Poissant *et al* [26]. Significant correlations found in the present study were also noted among all the metals studied, and may be due to the same source i.e., traffic especially automobiles.

TABLE 1

FAAS and GFAAS Analytical Conditions and Heating Program Temperature of Investigated Elements Conditions for FAAS

Element	Acetylene (L/min)	Air (L/min)	Wavelength (nm)	Slit Width (nm)	Lamp Current (mA)
Fe	2.0	17.0	248.3	0.2	30
Cu	2.0	17.0	324.8	0.7	15
Zn	2.0	17.0	213.9	0.7	15
Conditions for GFAAS					
Instrumental Conditions	Pb	Cd	Ni	Cr	Mn
Argon Flow (mL/min)	250	250	250	250	250
Sample Volume (µL)	20	20	20	20	20
Modifier (µL)	5	10	5	5	5
Heating Program Temperature ℃ (RAMP TIME (S), HOLD TIME (S))					
Drying 1	100 (5, 20)	100 (5, 20)	100 (5, 20)	100 (5, 20)	100 (5, 20)
Drying 2	140 (15, 15)	140 (15, 15)	140 (15, 15)	140 (15, 15)	140 (15, 15)
Ashing	700 (10, 20)	850 (10, 20)	1300 (10, 20)	1600 (10, 20)	1200 (10, 20)
Atomization	1800 (0, 5)	1650 (0, 5)	2500 (0, 5)	2500 (0, 5)	2300 (0, 5)
Cleaning	2600 (1, 3)	2600 (1, 3)	2600 (1, 3)	2600 (1, 3)	2600 (1, 3)

TABLE 2

Comparison of Trace Metal Contents in Palm Samples Using Three Different Methods [Cd and Ni (µg/Kg), Others (µg/g) ($\bar{x} \pm s$)]

Method	Cd	Ni	Cu	Pb	Zn	Mn	Fe	Cr
Microwave Digestion	188.1±8.2	66.2±6.1	4.9±0.4	1.62±0.1	1.6±0.1	0.81±0.1	7.2±0.7	0.88±0.1
Wet Digestion	180.4±7.1	60.4±6.2	4.6±0.5	1.55±0.1	1.7±0.1	0.73±0.1	7.9±0.8	0.78±0.1
Dry Ashing	177.5±6.2	63.3±6.1	4.1±0.4	1.49±0.1	1.8±0.2	0.77±0.1	7.5±0.6	0.75±0.1

TABLE 3

Observed and Certified Values (μg/g) of Elemental Concentrations in SRM (IAEA-336 Lichen) ($\bar{x} \pm s$)

	Certified Value	Observed Values					
		Dry Ashing	Recovery, %	Wet Digestion	Recovery, %	Microwave Digestion	Recovery, %
Cd	0.117	0.11±0.01	94	0.11±0.01	96	0.11±0.01	98
Cu	3.55	3.37±0.22	95	3.40±0.28	96	3.50±0.15	99
Mn	64	60±5	94	62±4	97	65±3	102
Pb	5	4.6±0.4	92	4.8±0.3	96	4.9±0.3	98
Zn	31.6	29.7±2.3	94	30.5±2.6	97	30.9±2.8	98
Fe	426[a]	410±26	96	418±37	98	422±15	99
Cr	1.03[a]	0.98±0.10	95	0.99±0.10	96	1.04±0.10	101

Note. [a]Not certified. Each value is the average of three separate digestions.

TABLE 4

Trace Metal Contents in Samples (Cd and Ni (μg/Kg), Others (μg/g)) From the Regions of Low Traffic Volume ($\bar{x} \pm s$)

Station	Vehicle/h	Cd	Ni	Cu	Pb	Zn	Mn	Fe	Cr
A1	174	56.4±5.4	46.6±3.4	2.1±0.2	0.22±0.02	0.9±0.1	0.43±0.03	3.9±0.3	0.28±0.02
A2	180	79.5±7.6	42.3±3.6	2.1±0.1	0.54±0.05	1.5±0.2	0.47±0.03	1.6±0.1	0.28±0.02
A3	192	87.1±7.8	40.1±3.5	3.8±0.3	0.50±0.05	0.8±0.1	0.63±0.05	2.5±0.4	0.40±0.02
A4	162	66.1±5.6	54.5±4.5	3.7±0.3	0.63±0.05	0.6±0.1	0.58±0.04	2.3±8.4	0.38±0.02
A5	162	90.7±7.8	41.5±3.6	3.6±0.3	0.57±0.05	1.7±0.2	0.50±0.04	3.1±0.5	0.34±0.02
A6	150	73.5±5.6	49.4±4.1	3.1±0.2	0.63±0.05	1.5±0.2	0.62±0.05	3.3±0.3	0.39±0.03
A7	156	95.4±7.5	24.4±2.1	3.3±0.2	0.74±0.06	0.9±0.1	0.69±0.06	3.2±0.2	0.48±0.04
A8	138	67.3±5.6	22.4±1.8	4.0±0.3	0.48±0.04	0.9±0.1	0.53±0.05	2.8±0.1	0.33±0.03
A9	120	85.6±7.2	34.2±3.1	3.0±0.2	0.53±0.04	0.7±0.1	0.48±0.04	3.0±0.2	0.58±0.05
A10	168	85.4±7.8	41.3±3.4	4.0±0.3	0.52±0.04	0.9±0.1	0.52±0.03	3.6±0.5	0.42±0.03
A11	132	62.2±5.4	36.5±2.8	3.6±0.3	0.56±0.04	0.8±0.1	0.56±0.05	2.9±0.2	0.48±0.04
Mean	158	77.2±12.8	39.4±9.7	3.3±0.7	0.54±0.13	1.0±0.4	0.55±0.08	2.9±0.6	0.39±0.09

TABLE 5

Trace Metal Contents in Samples (Cd and Ni (μg/Kg), Others (μg/g)) From The Regions of Moderate Traffic Volume ($\bar{x} \pm s$)

Station	Vehicle/h	Cd	Ni	Cu	Pb	Zn	Mn	Fe	Cr
O1	300	73.6±5.6	38.5±2.9	4.3±0.1	0.96±0.02	1.6±0.2	0.52±0.04	4.2±0.3	0.19±0.01
O2	330	43.2±4.0	47.3±3.7	2.3±0.2	0.77±0.01	0.9±0.1	0.43±0.03	6.4±0.1	0.24±0.02
O3	312	66.2±6.0	42.3±3.5	4.6±0.1	0.88±0.01	0.9±0.1	0.49±0.04	4.5±0.4	0.20±0.01
O4	240	78.3±5.6	44.4±3.6	3.1±0.3	0.62±0.05	2.5±0.3	0.44±0.04	4.0±0.3	0.38±0.03
O5	270	65.3±5.5	42.3±4.1	4.5±0.2	0.92±0.01	0.9±0.1	0.50±0.04	6.3±9.2	0.28±0.02
O6	288	76.2±6.0	50.3±4.2	3.0±0.2	0.73±0.06	0.9±0.1	0.63±0.05	3.6±0.3	0.62±0.05
O7	360	53.6±5.0	40.2±3.4	2.0±0.1	0.86±0.03	0.7±0.1	0.36±0.03	4.2±0.3	0.20±0.01
O8	288	80.1±7.2	63.5±5.8	4.5±0.4	0.82±0.07	1.8±0.2	0.47±0.04	4.0±0.3	0.60±0.05
O9	252	57.8±5.0	43.1±3.9	3.8±0.3	0.78±0.02	1.6±0.2	0.35±0.03	6.7±0.3	0.18±0.01
O10	270	83.1±7.5	45.4±4.1	5.6±0.1	0.96±0.01	0.8±0.1	0.42±0.03	8.1±0.2	0.36±0.03
O11	264	77.1±6.5	43.6±3.5	2.6±0.2	0.84±0.03	0.8±0.1	0.46±0.04	7.3±0.1	0.18±0.01
Mean	289	68.6±12.6	45.5±6.8	3.7±1.1	0.83±0.10	1.2±0.6	0.46±0.08	5.4±1.6	0.31±0.16

TABLE 6

Trace Metal Contents in Samples (Cd and Ni (μg/Kg), Others (μg/g)), From the Regions of High Traffic Volume ($\bar{x} \pm s$)

Station	Vehicle/h	Cd	Ni	Cu	Pb	Zn	Mn	Fe	Cr
Y1	516	96.3±8.6	53.3±4.8	7.4±0.3	0.82±0.08	1.8±0.1	0.96±0.08	6.9±0.6	0.79±0.07
Y2	438	94.3±8.8	72.4±6.6	4.5±0.4	0.64±0.05	1.9±0.1	0.75±0.07	8.8±0.5	0.48±0.04
Y3	510	95.4±9.2	54.1±5.0	5.8±0.5	0.92±0.08	1.9±0.2	0.73±0.06	4.4±0.4	0.89±0.04
Y4	540	175.3±6.4	63.6±5.7	8.5±0.4	0.83±0.07	0.9±0.1	0.81±0.07	8.9±0.3	0.99±0.04
Y5	480	173.1±7.5	83.2±7.6	7.4±0.4	1.68±0.05	1.6±0.3	0.90±0.09	5.6±0.5	0.59±0.05
Y6	480	188.1±8.2	66.2±6.1	4.9±0.4	1.62±0.06	1.6±0.1	0.81±0.07	7.2±0.7	0.88±0.08
Y7	450	182.5±7.6	62.1±5.4	8.4±0.3	0.73±0.06	1.8±0.2	0.94±0.07	4.4±0.4	0.69±0.06
Y8	492	171.4±6.5	54.5±4.5	7.8±0.3	0.86±0.07	2.6±0.3	0.74±0.06	5.3±0.4	0.58±0.05
Y9	522	105.6±9.6	69.2±5.9	4.1±0.4	1.98±0.09	3.5±0.4	0.95±0.08	4.6±0.3	0.86±0.07
Y10	474	125.4±7.4	73.1±6.3	4.5±0.4	1.87±0.07	1.6±0.2	0.90±0.08	8.2±0.4	0.69±0.06
Y11	528	100.1±8.6	66.2±5.4	9.6±0.3	0.93±0.08	0.8±0.04	0.64±0.05	9.4±0.5	0.78±0.07
Y12	480	174.3±5.9	51.8±4.7	4.6±0.3	1.56±0.05	0.8±0.06	0.80±0.06	4.0±0.2	0.79±0.07
Y13	420	90.2±8.1	41.7±3.8	7.0±0.3	0.76±0.06	1.4±0.1	0.82±0.07	4.7±0.4	0.79±0.03
Mean	487	136.1±41.2	62.4±11.1	6.5±1.9	1.17±0.49	1.7±0.7	0.83±0.09	6.3±1.9	0.75±0.14

TABLE 7

Correlation Coefficients Between Investigated Metal Concentrations (r=95%)

	Cd	Ni	Cu	Pb	Zn	Mn	Fe	Cr
Ni	0.939							
Cu	0.973	0.990						
Pb	0.838	0.976	0.935					
Zn	0.922	1.000	0.986	0.981				
Mn	0.500	0.958	0.939	0.756	0.870			
Fe	0.617	0.863	-0.776	0.616	0.874	0.520		
Cr	0.999	0.909	0.959	0.847	0.899	0.998	0.573	
Number of Vehicle	0.866	0.989	0.958	0.997	0.992	0.801	0.928	0.838

In conclusion, as pointed in the literature[17,19,25,27] and also in the light of our findings, the date palm (*Phoenix dactylifera*) leaves are suitable as a biomonitor for atmospheric heavy metal pollution from traffic. Significant correlations can be obtained between traffic levels and heavy metal concentrations.

ACKNOWLEDGEMENT

The authors are grateful for the financial support of the Units of the Scientific Research Projects of Gaziosmanpasa University, Pamukkale University and Erciyes University.

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(*Received April* 18, 2005 *Accepted October* 14, 2005)