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SPREADING PELLITORY (*PARIETARIA JUDAICA* L.): A POSSIBLE BIOMONITOR OF HEAVY METAL POLLUTION

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Abstract

Parietaria judaica L. (Spreading pellitory) is a herbaceous plant that grows wildly in the urban areas in Turkey. Leaves of *P. judaica* were tested as a possible biomonitor of heavy metal pollution in Istanbul. Fifty three sites (urban, urban park, roadside, coast, suburban and rural) in and around Istanbul were investigated. Concentrations of Pb, Cd, Cu and Zn were determined in unwashed and washed leaves and soils collected from a wide range of sites with different degrees of metal pollution. Differences between the unwashed and washed samples varied according to the metal pollutant levels. The concentrations of heavy metals in the leaves of *P. judaica* increased along with the urbanization of the sites. Significant correlations were obtained between the heavy metal concentrations in surface soil and washed leaf samples. *P. judaica* was found to be a useful biomonitor of the investigated heavy metals.

Introduction

Biomonitors are organisms that provide quantitative information on environmental quality (Markert *et al*., 2003). Using biological materials in the determination of environmental pollution as a biomonitor is a cheap and reliable method. The morphological, physiological, and other reactions of different types of terrestrial plants are now used for biomonitoring of trace elements as well as monitoring the environmental quality (Ozturk *et al*., 2008). Many studies have been undertaken in Turkey related to the heavy metal biomonitoring features of plants (Aksoy & Ozturk 1996-1997; Aksoy & Sahin, 1999; Aksoy *et al*., 1999, 2000a, 2000b; Baycu *et al*., 2003; Aksoy & Demirezen, 2006; Yilmaz *et al*., 2006; Akguc *et al*., 2008; Celik *et al*., 2009; Yasar *et al*., 2010).

The leaves of herbaceous plants have been used to detect the deposition, accumulation and distribution of heavy metal pollution (Aksoy *et al*., 1999; Aksoy, 2008). The comparison of washed and unwashed leaves provide a reasonably reliable measure of the total aerial fallout of Pb, Cd, Cu and Zn, in the city of Kayseri in Turkey (Aksoy 2008).

According to Wittig (1993) the basic criteria for the selection of a species as a biomonitor are that it should be represented in large numbers all over the monitoring area, have a wide geographical range, should be able to differentiate between airborne and soil borne heavy metals, be easy to sample and there should be no identification problems. *P. judaica* was selected for biomonitoring studies because it fulfills all the basic criteria given by Wittig, (1993).

The aim of this study was to determine Pb, Cd, Cu and Zn concentrations in surface soil and in unwashed and washed leaves of *P. judaica*. It was selected as a possible biomonitor of heavy metal pollution because it occurs widely in both urban and rural areas in Istanbul, has a wide geographical range and ecological distribution throughout the world, and is easy to sample.

Material and Methods

Study area: Istanbul is the largest city on population basis, located in the north-west of Turkey with 40 administrative districts and a population of nearly 13 million inhabitants. The area of this rapidly growing city is around 5750 km^2. The environment of the city receives pollution in particular heavy metals from different sources: transportation, industrial activities, burning of fossil fuels, agriculture and other human activities (Yetimoglu *et al*., 2007 and Yasar *et al*., 2010)

Plant material, site selection and treatment conditions: *P. judaica* L. (spreading pellitory) belongs to the family *Urticaceae*. It is a perennial herb, with individual plants consisting of many shoots emerging from a common rootstock, most of them flowering copiously in spring. The plant has pink or red hairy stems, leaves with smooth margins, and tiny white or pink flowers attached to the stems. Flowers are hermaphrodite or female, and pollination is anemophilous. *P. judaica* is native to the Europe, S.E. Asia, N. Africa, Australia and North America (Davis, 1982).

Samples of plants and soils were collected from different sites during August, 2010, the number of sites from each category sampled was as follows: roadside = 15, urban park = 9, coast = 5, suburban = 7, urban = 12 and control (rural) = 5. Preferred urban and roadside sites for sampling were the most crowded parts of the city centre. The traffic density of this road was estimated to be 3000 vehicles per hour. Samples from urban park were taken from Kadikoy and Uskudar districts. Suburban sites were chosen from Cekmekoy, Umraniye and Uskudar districts. Preferred coastal sites for sampling were coast right next to the Eminonu and Uskudar district. For rural area, samples were collected from Heybeliada, about 2.6 miles away from Istanbul city.

Samples were taken by hand using vinyl gloves and carefully packed into the polyethylene bags. These were divided into 2 sub-samples; some of them were thoroughly washed several times with tap water followed by distilled water to remove dust particles in a standardized procedure, and then oven dried at 80°C for 24 h. The drying of the collected materials is important since it protects the plant material from microbial decomposition and also ensures a constant reference value by determining dry weight in contrast to fresh weight, which is difficult to quantify (Markert, 1993; Aksoy *et al*., 2005). To ensure the uniform distribution of metals in the sample, all materials were milled in a micro-hammer cutter and sieved through a 1.5mm sieve. Dried and milled samples were powdered and kept in clean polyethylene bottles. In addition, the soil samples were collected with a stainless steel crab. They were air dried and passed through a 2 mm sieve. After homogenization, samples of soils were placed in clear paper bags and stored for analysis.

Heavy metal quantification: Samples (0.5g d. wt.) were digested with 10mL of pure HNO_3 using a CEM Mars 5 (CEM Corporation Mathews, NC, USA) microwave digestion system. The digestion conditions were as follows; the maximum power was 1200 W, the power was at 100 %, the ramp time was set for 20 min., the pressure was 180 psi, the temperature was 210 °C and the hold time was 10 min. After digestion, solutions were evaporated to near dryness in a beaker. The volume of each sample was adjusted to 10mL using 0.1 M HNO_3. The determination of the elements in all samples was carried out by using a Varian Inductively Coupled Plasma – Optical Emission Spectrometry (ICP–OES). The stability of the device was evaluated after every ten samples by examining an internal standard. Reagent blanks were also prepared to detect any potential contamination during the digestion and analytical procedure. All chemicals used in this study were of analytical reagent grade (Merck, Darmstadt, Germany). Peach leaves (NIST, SRM-1547) were used as reference material and also all analytical procedures were performed for reference materials. Samples were analyzed in triplicate.

Statistical analysis: Statistical Package for the Social Sciences (SPSS) statistical program was used for statistical analysis. Significance of comparison of means by ANOVA (F-test) was indicated. The t-test analyses was carried out among the washed and unwashed samples, analyzed metals showing difference were identified. Correlations between soil and the unwashed leaves were calculated (Table 2).

Results and Discussion

The mean concentrations of heavy metals (Pb, Cd, Cu and Zn) found in unwashed and washed leaves of *P. judaica* in different sites are presented in Figs. 1a & 2a. Mean Pb and Cd concentrations in roadside samples are slightly higher than the urban sites, significantly higher than coastal sites in washed and unwashed leaves. Zn concentration in the coastal site is significantly higher than other areas in washed and unwashed leaves. Mean concentrations of heavy metals in the soils supporting *P. judaica* in the same areas are presented in Figs. 1b & 2b. Pb, Cd, Cu and Zn concentrations in roadside sites are significantly higher than other sites in soil. A similar finding is reported by Yilmaz *et al*., (2006) from Thrace region (Turkey) who found a significant correlation between traffic density and Pb, Cd, Cu and Zn concentrations. High heavy metal content in the soils and plant samples from roadside and urban sites is mostly due to the density of the traffic which is considered as one of major sources of heavy metal contamination.

Washing the leaves significantly reduced the Pb, Cd, Cu and Zn concentrations in *P. judaica* from all sites. A comparison of the amount of metal extracted from unwashed with that from washed leaves (Table 1), shows that removal of the metals from the leaves by washing was significantly different; for example 14-48% of the Pb was removed by the washing procedure, depending on the pollutant level at the sampling site. The ability to distinguish airborne and soil borne contamination was assessed by washing the leaves. The results given in Table 1 indicate that there was substantial aerial deposition on the leaves for all four elements, which were removed by washing procedure.

Table 1. Total percentage of Pb, Cd, Cu and Zn removed from the leaves of *P. judaica* through washing procedure.

Site	Pb	Cd	Cu	Zn
Roadside	48,43	17,95	30,54	40,63
Coast	44,30	10,77	25,14	30,08
Urban	37,88	15,71	31,70	41,63
Urban park	37,06	12,90	26,19	37,57
Suburban	25,62	8,62	21,66	32,85
Control	14,063	7,69	11,46	13,77

Table 2. Relationships between heavy metal concentration in surface soil and the washed leaves of *P. judaica*.

	Element	Sample number	*r*
P. judaica	Cd	53	0,432**
	Cu	53	0,518***
	Pb	53	0,286**
	Zn	53	0,608***

*(Key: r, correlation coefficient; **p<0.01, ***, p<0.001 significant).*

A least squares linear regression was obtained for each of the metals, Pb, Cd, Cu and Zn, between concentrations of the element in surface soils and in the washed leaves of *P. judaica*. Table 2 shows the values of the correlation coefficient (*r*) for each heavy metal. A perusal of the table shows that Zn and Cu are highly significant at $p<0.001$ except Pb and Cd which are also significant at $p<0.01$. It can therefore be inferred that with an increase in the amount of heavy metals in soil due to percolation the uptake of heavy metals by *P. judaica* also increases. Aksoy (2008) investigated *Cichorium intybus* as a biomonitor of heavy metal pollutions in Kayseri. He reported that correlations between various elements in washed leaves and soils were highly variable (e.g. Pb=0.435, Cd=0.690, Zn=0.848 and Cu=0.803). Lead is generally added to the environment by aerial deposition alongside the roads in proportion with the density of traffic and distance from the roadside. Sawidis *et al*.,

(1995) studied air pollution with heavy metals in Thessaloniki city (Greece) using trees as biological indicators and reported that high levels of heavy metals came from vehicular emissions. Many plants growing on soils in nature contain large amounts of metals essential for plants such as cobalt, copper, iron, manganese, nickel and zinc, but also elements which are not essential for plant growth such as aluminum, cadmium, lead and thallium, plants can remove these metals to a significant extent (Ernest, 2003). Lead is less mobile than Cd and Zn (Koeppe, 1981) and, although uptake from the soil can raise foliar Pb concentrations, an uptake of Pb through the root system has been demonstrated under greenhouse conditions as well. In the field most uptakes have been demonstrated to be through the leaves (Koeppe, 1981).

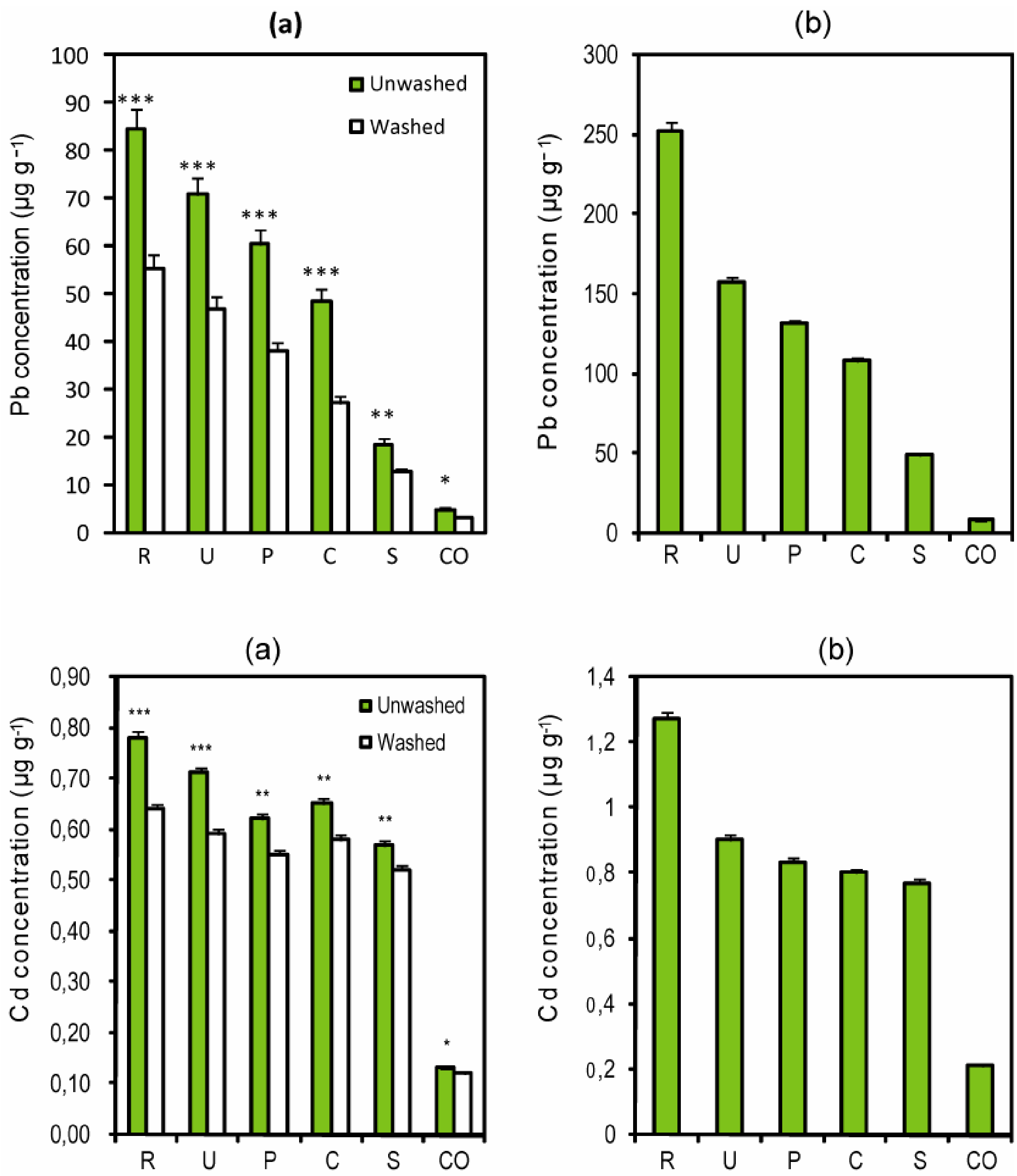

Fig. 1. Mean Pb and Cd concentrations (µgg^{-1} dry weight) in washed and unwashed leaves of (a) *P. judaica* and also equivalent concentrations of the metals in soil (b) together with S.E. bars. Significance of differences between washed and unwashed plants, from paired t-test, are indicated above the columns. (Keys: *p<0.05; **p<0.01; ***p<0.001 significant; R, Roadside; U, Urban; P, Urban park; C, Coast; S, Suburban and CO, Control).

Table 3 presents a comparison of the toxic heavy metal concentrations (Ross, 1994). Since concentration of heavy metals in *P. judaica* do not exceed the upper limit, studied sites of Istanbul are not highly polluted by Pb, Cd, Cu and Zn. The levels do not exceed the upper limit. However, all sites (except rural area) show values in which the upper limit is higher than the minimum levels of contamination given by Ross (1994). This high concentration may be due to the aerial deposition of heavy metal over a long time period.

Table 3. Comparison of heavy metal concentrations (µg g-1 dry wt) considered toxic or contaminated,taken from the literature (adapted from Ross, 1994), with values from this study.

Element	Concentrationsin soil considered toxic	Concentration in contaminated plants	Present results	
			Soil	Plants
Pb	100-400	30-300	8,16-252	4,87-88,60
Cd	3-8	0,03-3,8	0,21-1,27	0,13-0,78
Zn	70-400	100-400	49-205	37-95,85
Cu	60-125	20-100	25,89-112	15-37,61

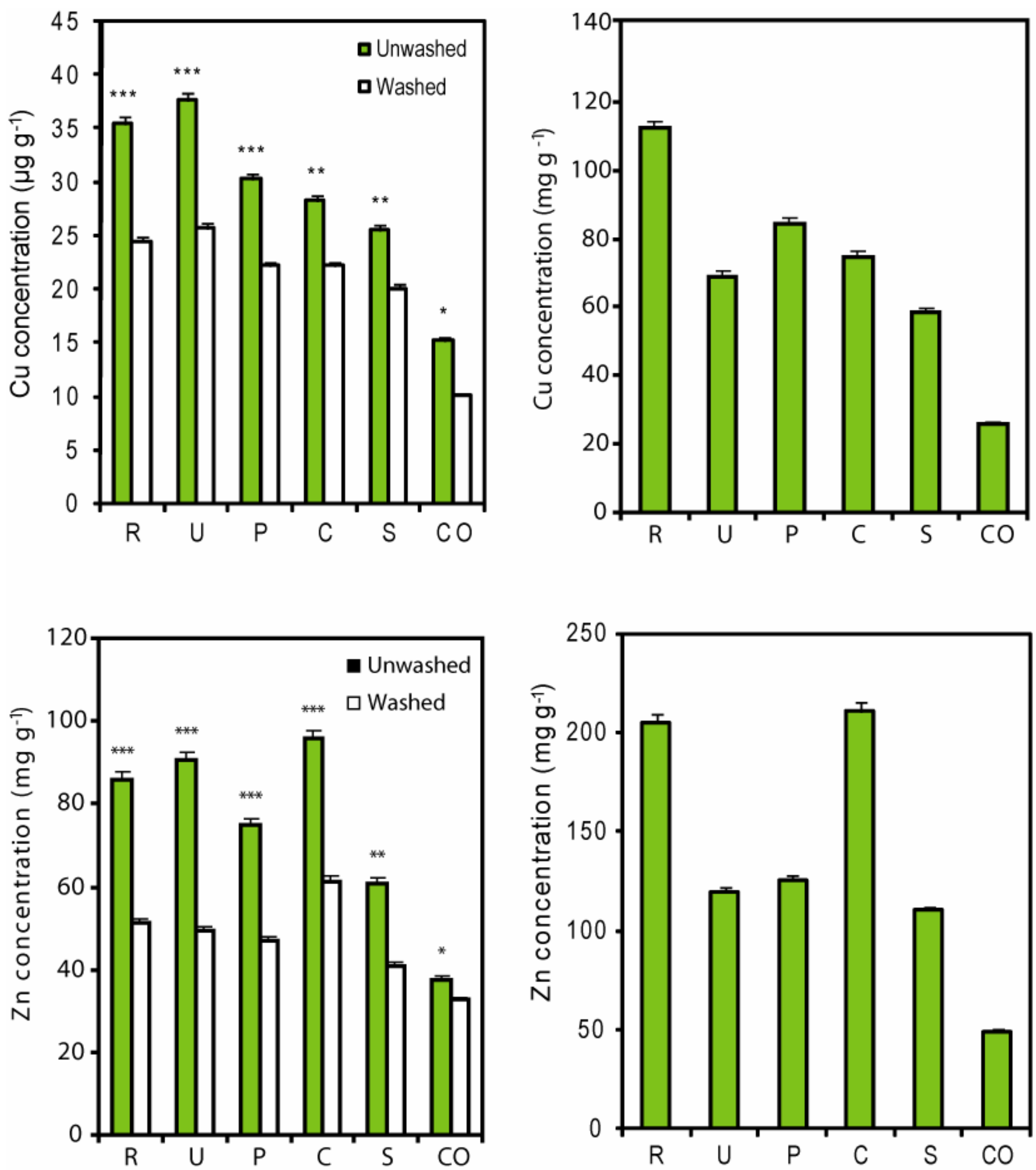

Fig. 2. Mean Cu and Zn concentrations (µgg^{-1} dry weight) in washed and unwashed leaves of (a) *P. judaica* and also equivalent concentrations of the metals in soil (b) together with S.E. bars. Significance of differences between washed and unwashed plants, from paired t-test, are indicated above the columns. (Keys: *p<0.05; **p<0.01; ***p<0.001 significant; R, Roadside; U, Urban; P, Urban park; C, Coast; S, Suburban and CO, Control).

Conclusion

P. judaica shows all the criteria for the selection of a species as a biomonitor and our study fully supports the view that it can be a useful biomonitor all through, Turkey, S.W. Asia, Eorupe, N. Africa, Australia, and North America, because a highly significant linear regression was obtained for each of the metals Pb, Cd, Cu and Zn between concentrations of the element in surface soil and in the washed leaves of plant.

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