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A Biomonitor of Heavy Metals on Ruderal Habitats in Turkey - *Diplotaxis tenuifolia* (L.) DC.

(Suatu Biopenunjuk bagi Logam Berat pada Habitat Rudera di Turki – *Diplotaxis tenuifolia* (L.) DC.)

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ABSTRACT

Diplotaxis tenuifolia *is a medicinally important perennial plant species, distributed widely alongside the roads in Turkey. The samples were collected from 54 sites, including highways, sideways, industrial areas, urban centres and rural environs. Both the plant and soil samples were analysed to determine the concentrations of different metals using AAS. The results showed that in the soil samples copper and lead were highest near highway 45.533 and 2.865 mg/kg, respectively; but lowest values of copper were determined around industrial areas (3.514 mg/kg), latter however showed higher concentrations of cadmium (0.726 mg/kg) and iron (82.766 mg/kg). The lead as well as iron were the lowest around sideways 1.917 mg/kg and 54.073 mg/kg, respectively, whereas chromium concentrations in the soils were highest near sideways (18.397 mg/kg) and lowest around industrial areas (0.182 mg/kg). The sideways showed very low nickel concentrations (0.271 mg/kg), as compared to the rural areas which had higher nickel concentrations (0.726 mg/kg). No cadmium was detected in the urban soil samples. In the plants copper and chromium were higher in the urban areas 50.130 and 0.238 mg/kg, respectively. The former was lowest around sideways (32.377 mg/kg) and latter around highways (0.114 mg/kg). Both nickel and cadmium were higher in the samples from industrial areas 0.238 and 0.016 mg/kg, respectively. Their values around the highways were lowest 0.182 and 0.005 mg/kg. The samples from urban sites revealed highest values of lead (3.474 mg/kg) and iron (61.304 mg/kg), but the values of lead were lowest around sideways (2.420 mg/kg) and those of iron in the vicinity of industrial areas (20.600 mg/kg). All these findings depict that there is some aerial deposition of these metals on the leaves. A significant correlation is seen between the plants and the soils.*

Keywords: Biomonitor; Diplotaxis tenuifolia; *heavy metals; Turkey*

ABSTRAK

Diplotaxis tenuifolia *ialah suatu spesies tumbuhan saka yang penting sebagai ubat, tertabur secara meluas di tepi jalan di Turki. Sampel telah dikutip dari 54 tapak, termasuk lebuh raya, tepi jalan raya, kawasan industri, pusat bandar dan persekitaran desa. Kedua-dua sampel tumbuhan dan tanih telah dianalisis untuk menentukan kepekatan logam berbeza menggunakan AAS. Hasil menunjukkan dalam sampel tanih, tembaga dan plumbum adalah paling tinggi berdekatan lebuh raya masing-masing 45.533 dan 2.865 mg/kg, tetapi nilai paling rendah bagi tembaga telah ditentukan di sekeliling kawasan industri (3.514 mg/kg), walau bagaimanapun menunjukkan kepekatan lebih tinggi bagi kadmium (0.726 mg/kg) dan besi (82.766 mg/kg). Plumbum dan besi adalah paling rendah di sekeliling tepi jalan, masing-masing 1.917 mg/kg dan 54.073 mg/kg, manakala kepekatan kromium di dalam tanih adalah paling tinggi dekat tepi jalan (18.397 mg/kg) dan paling rendah di sekeliling kawasan industri (0.182 mg/kg). Tepi jalan menunjukkan kepekatan nikel paling rendah (0.271 mg/kg), dibandingkan dengan kawasan desa yang mempunyai kepekatan nikel paling tinggi (0.726 mg/kg). Tiada cadmium telah dikesan dalam sampel tanih bandar. Dalam tumbuhan, tembaga dan kromium adalah paling tinggi di kawasan bandar masing-masing 50.130 dan 0.238 mg/kg. Tembaga adalah paling rendah di tepi jalan (32.377 mg/kg) dan kemudian di sekeliling lebuh raya (0.114 mg/kg). Kedua-dua nikel dan cadmium adalah paling tinggi dalam sampel dari kawasan industri masing-masing 0.238 dan 0.016 mg/kg. Nilai mereka di sekeliling lebuh raya adalah paling rendah 0.182 dan 0.005 mg/kg. Sampel dari tapak bandar menunjukkan nilai paling tinggi bagi plumbum (3.474 mg/kg) dan besi (61.304 mg/kg), tetapi nilai bagi plumbum adalah paling rendah di sekeliling tepi jalan (2.420 mg/kg) dan nilai bagi besi di sekitar kawasan industri (20.600 mg/kg). Semua penemuan ini menunjukkan bahawa mungkin terjadi penumbukan dari udara bagi logam yang berkenaan pada daun. Suatu korelasi yang signifikan telah dilihat antara tumbuhan dan tanih.*

Kata kunci: Biopenunjuk; Diplotaxis tenuifolia; *logam berat; Turki*

INTRODUCTION

Higher plants have frequently been used to biomonitor different kinds of pollution during the last 40-50 years (Aksoy et al.1999; Djingova & Kuleff 1993; Edem et al. 2009; Pandey 2006; Prasad 2008). Most of these investigations deal with perennial species rather than annuals or short-living perennials (Aksoy et al. 2000; Ashraf et al. 2010; Atiq-ur-Rehman & Iqbal 2008; Boularbah et al. 2006; Celik et al. 2009; Gucel et al. 2009(a), 2009(b); Jarup 2003; Ozturk et al. 2008; Yilmaz et al. 2006).

Diplotaxis tenuifolia plants are found alongside the roads in Turkey. Large populations are found in the States of Afyon, Kutahya and Isparta as well as West Anatolia and Istanbul (Figure 1). The distributional pattern of this plant alongside the roads prompted us to undertake an investigation on its biomonitoring role because of its economical and therapeutical importance. In some of the European countries this plant is used as salad or cooked as a vegetable (Sakcali & Serin 2009). In Turkey *D. tenuifolia* shows luxurious growth all along the roads under heavy traffic pollution. In view of this our aim here was to investigate the status of heavy metals in the soil and the plants, so as to look at the possibility for its use as a pollution biomonitor on the roadsides.

MATERIALS AND METHODS

Field trips were conducted in 12 cities of West Anatolia and European part of Turkey, including; Edirne (41° 32′ North; 26° 34′ East); Tekirdag (40° 57′ North; 27° 30′ East); Istanbul (41° 5′ North; 28° 50′ East); Kocaeli (40° 45′ North; 29° 43′ East); Sakarya (40° 48′ North; 30° 23′ East); Yalova (40° 39′ North; 29° 15′ East); Bilecik (40° 09′ North; 29° 59′ East); Kutahya (39° 26′ North; 29° 59′ East); Afyon (38° 46′ North; 30° 33′ East); Isparta (37° 49′ North; 30° 33′ East); Burdur (37° 43′ North; 30° 17′ East); Denizli (37° 47′ North; 29° 06′ East) (Figure 1). In all, 54 samples of plants were collected and 54 soil samples from the upper 0-20 cm zone of soils were also taken from the same spots. The collections from the upper soil horizon were made because the root system of this species is well spread in this zone.

The collection sites were divided into the highways, sideways, industrial areas, urban conglomerations and rural areas. Highway sites were chosen from main roads, sideway sites from relatively low traffic activity areas, industrial sites near industrial establishments, urban sites along the roads passing through the city centres and rural sites alongside the roads passing through countryside where traffic activity was the lowest.

SAMPLE COLLECTION AND PREPARATION

The plant samples were taken from each one of the 54 localities during the month of October, together with a total of 2 kg soil samples from 0-20 cm depth, using stainless steel shovel. The fresh weight of each plant sample was 200 g and these were brought to the laboratory, dried, milled and prepared for analysis together with the soil samples following the method given in detail in Aksoy and Ozturk (1996). The samples were investigated for their metal contents at the Cekmece Nuclear Research and Training Center, Turkey. The methods are for these determinations are dicussed at length in the paper published by Aksoy and Ozturk (1996). The equipment used was atomic absorption spectrometer (Varian SpectrAA 200). The accuracy and recovery rates were within 95% range as verified by IAEA's certified reference material. The statistical evaluations were done according to Aksoy and Ozturk (1997).

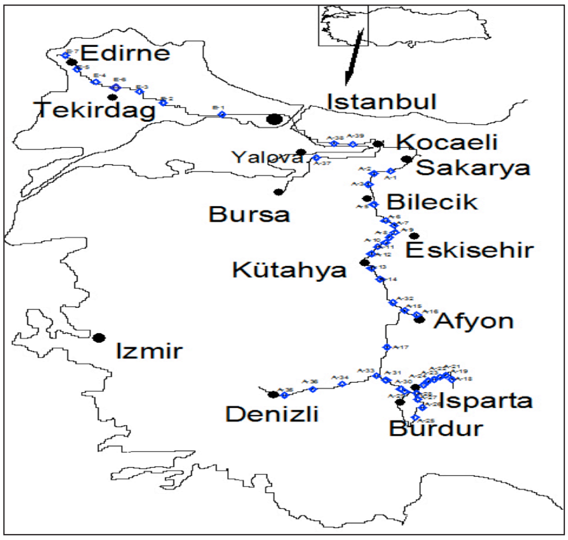

FIGURE 1. Collection sites of *Diplotaxis tenuifolia* in Turkey

RESULTS AND DISCUSSION

The important rule for the selection of a plant as a biomonitor is its representation in the form of big populations all over the area, should be widely distributed, able to differentiate between air/soil borne metals, easy and inexpensive to sample and correctly identified (Markert 1993; Ozturk & Turkan 1993; Wittig 1993).

D. tenuifolia possesses these criteria and can be used as a biomonitor all through natural distributional range. Table 1 shows the values of different metals found in *D. tenuifolia* plant samples and soils from different collection sites. An evaluation of the results related to the unwashed leaves shows that heavy metal contents in industrial site and urban roadside are slightly higher than the urban, suburban sites and significantly higher than rural sites (Figures 1 & 2).

A significant linear regression was obtained between the concentrations of metals in upper soil samples and unwashed plant. Mean values of heavy metals in the plant samples and soils are shown in Table 1. Mean values of copper in the soils are highest near highway (45.533) and lowest around industrial areas (3.514), in plants mean values are highest in urban areas (50.130) and lowest around sideways (32.377).

TABLE 1. Concentrations of heavy metal in the plants and soils

	D. tenuifolia		Soil	
Cu	Mean	SD	Mean	SD
Urban	50.130	12.458	26.590	9.381
Highway	33.003	15.920	45.533	23.615
Sideway	32.377	12.812	25.173	12.636
Rural	32.940	10.926	46.881	19.849
Industry	41.928	14.549	23.023	3.514

	D. tenuifolia		Soil	
Cr	Mean	SD	Mean	SD
Urban	0.238	0.387	0.519	0.174
Highway	0.114	0.168	0.423	0.289
Sideway	0.118	0.253	18.397	51.479
Rural	0.078	0.123	0.286	0.236
Industry	0.164	0.229	0.182	0.176

	D. tenuifolia		Soil	
Ni	Mean	SD	Mean	SD
Urban	0.236	0.095	0.275	0.141
Highway	0.182	0.085	0.281	0.186
Sideway	0.260	0.162	0.271	0.244
Rural	0.328	0.134	0.726	1.036
Industry	0.391	0.204	0.461	0.172

	D. tenuifolia		Soil	
Cd	Mean	SD	Mean	SD
Urban	0.006	0.007	0.000	0.000
Highway	0.005	0.007	0.002	0.003
Sideway	0.009	0.008	0.001	0.003
Rural	0.006	0.008	0.002	0.003
Industry	0.016	0.014	0.004	0.003

	D. tenuifolia		Soil	
Pb	Mean	SD	Mean	SD
Urban	3.474	0.665	2.425	1.139
Highway	2.879	0.989	2.865	2.064
Sideway	2.420	1.104	1.917	1.547
Rural	3.123	0.697	2.392	1.790
Industry	3.240	0.333	2.634	1.603

	D. tenuifolia		Soil	
Fe	Mean	SD	Mean	SD
Urban	61.304	40.075	80.846	24.960
Highway	29.582	33.135	74.421	38.212
Sideway	22.814	22.146	54.073	22.650
Rural	22.141	23.192	76.650	28.900
Industry	20.600	14.407	82.766	13.916

Copper is an essential elements for plant growth. Normal Cu^{++} plant concentrations above 20 $\mu g g^{-1}$ are considered toxic (Kanoun-Boule et al. 2008). Our results showed that copper concentrations in soil around highways and in plants in all sampling stations are above the limits. Mean chromium concentrations in the soils are highest near sideways (18.397) and lowest around industrial areas (0.182), but in plants mean values are highest in urban areas (0.238) and lowest around highways (0.114).

In the case of mean nickle, concentrations in the soils are highest around rural areas (0.726) and lowest around sideways (0.271), mean values in plants are

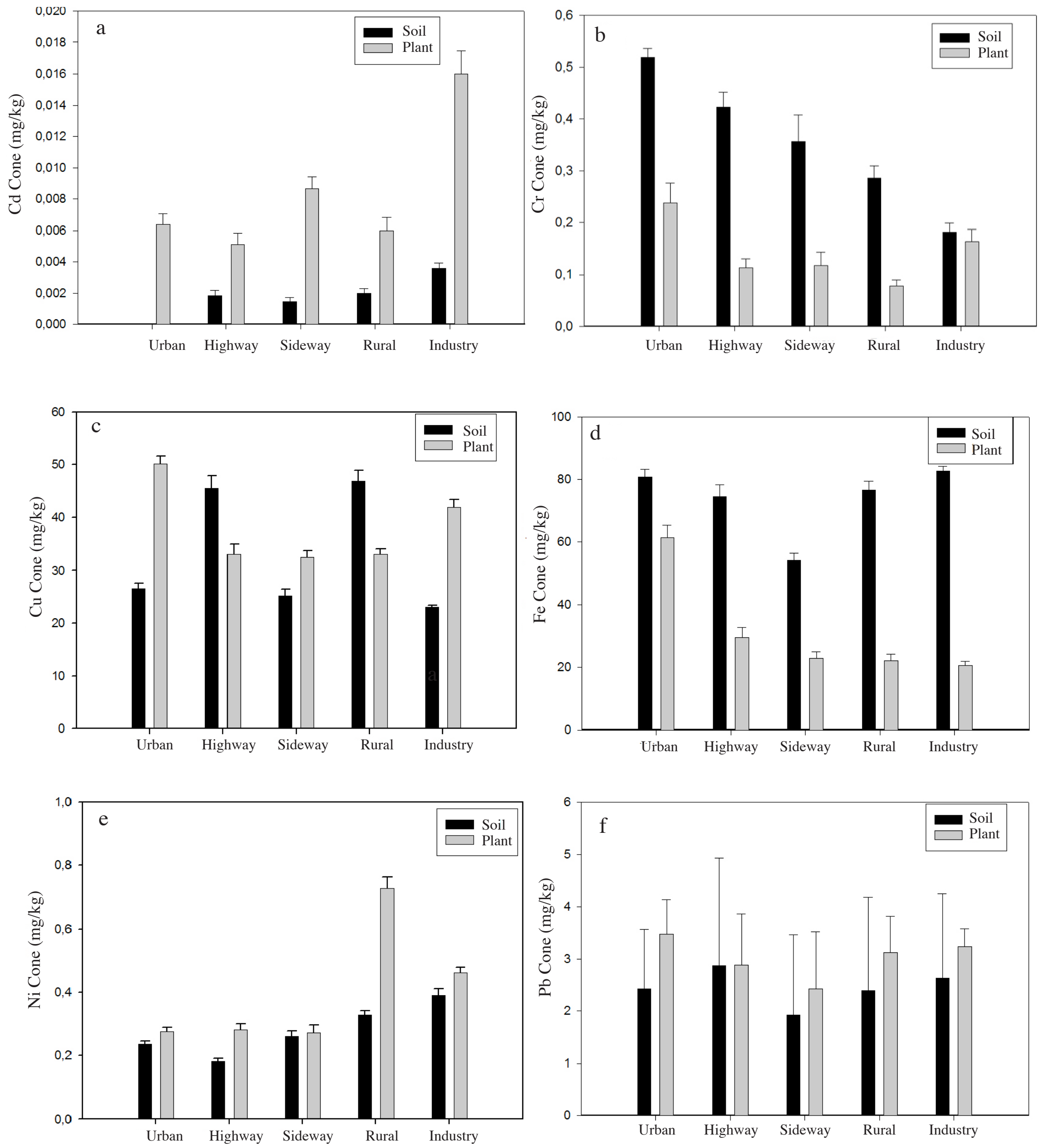

FİGURE 2 (a,b,c,d,e,f). Mean heavy metal values in *D. tenuifolia* plants and soils from the sampled habitats

highest around industrial areas (0.238) and lowest around highways (0.182). Tomasevic et al. (2004) and Cicek and Koparal (2004) found higher nickel concentrations in soil during their surveys. Similar results obtained by many other works.

The mean cadmium concentrations in the soils are highest around industrial areas (0.726) and lowest around urban areas (0.000), whereas in plants mean values are highest around industrial areas (0.016) and lowest around highways (0.005). The higher mean Cd concentrations in the sites along the highway can be attributed to the accumulation of dust originating from vehicular traffic and biotic activities (Memon et al. 2008).

The highest mean values of lead in the soils were recorded from highways (2.865) and lowest around sideways (1.917), but in plants the mean values are highest in urban areas (3.474) and lowest around sideways (2.420). Some studies have been done on the soils from upper layers of soil alongside the roads. The results have shown that a good correlation exists between traffic density and some metal concentrations. Some of these metals are less mobile than others, but an uptake from soils can lead to an increase in the levels in leaves. The experimental evidences clear depict an uptake through leaves. Some studies (Aksoy & Ozturk 1996, 1997; Markert 1993; Sawidis et al. 1995; Sesli 2004; Viard et al. 2004) related to the roadside pollution have shown that the values of deposition from air varys [Pb] >[Cd], depending on the metal. These reports fully coincide with our findings. Although Dietl et al. (1996) reported limit concentrations for Cd and Pb as 5

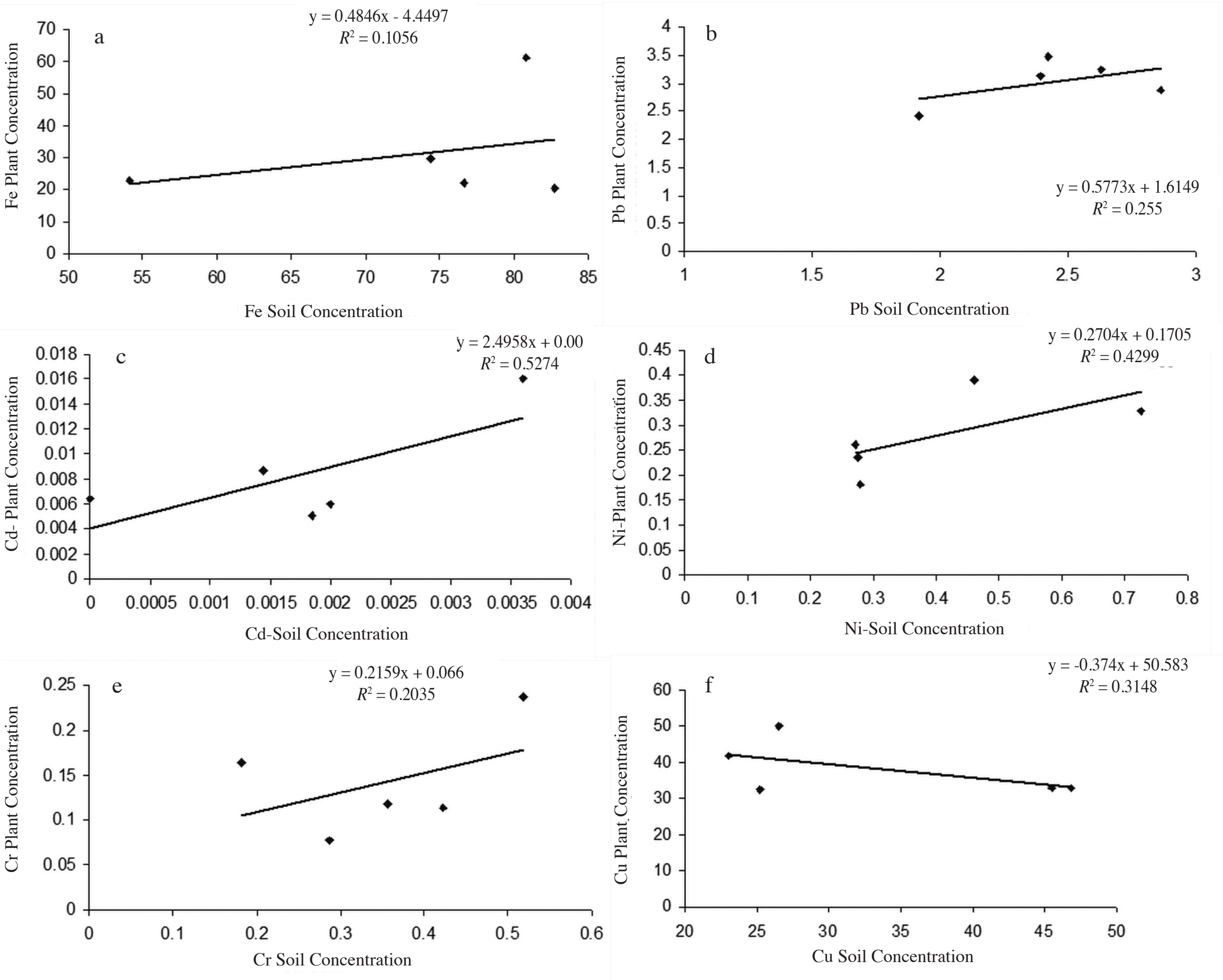

FIGURE 3. Correlations between the metal levels in the plants and soils of *Diplotaxis tenuifolia*

and 250 μgg^{-1}, respectively, our samples show value lower than these limits. In general, levels of Pb in soil next to the highway may be linked to traffic intensity as reported by (Chen et al. 2005; Garcia & Millan 1998; Sawidis et al. 1995). Similar findings have been reported by (Markert 1993) in their report.

In general, plant foliar concentration of 0,05-3 μgg^{-1} Pb are regarded as an indicator of Pb pollution in the environment. Aerial deposition and foliar uptake of Pb significantly contribute to the aboveground concentrations as suggested by (Markert 1993). Pb levels measured by us were higher than these limit values indicating Pb pollution as suggested by Chen et al. (2005).

The soils from the industrial areas show higher mean concentrations of iron (82.766) and lowest around sideways (54.073), in plants mean values are highest around urban areas (61.304) and lowest around industrial areas (20.600). Studies on the uptake of heavy metals from air and soil by some plant taxa clearly reveal that the values of Cu and Pb in plants are related with aerial deposition instead of soil, whereas presence of Ni and Cd are directly correlated with the deposition from air and availability in soil (Figure 3).

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