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A Study of Trace Element Contents in Plants Growing at Honaz Dagi-Denizli, Turkey

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Abstract

Denizli is one of the rapidly developing states in the West Anatolian Region of Turkey. Keeping this in view, 30 different plants were selected to study their potential as biomonitors of trace elements like Pb, Cd, Ni, Zn, Fe and Mn ($\mu g\ g^{-1}$, dry weight). The samples were collected from two different altitudes of Honaz Dagi, a mauntain overlooking at state of Denizli. The concentrations of trace elements were determined by flame atomic absorption spectrometry (FAAS). The mean concentrations determined at 1000 m altitude ranged between 0.273 to 0.488, 0.099 to 0.488, 0.306 to 0.682, 1.017 to 3.744, and 0.148 to 0.674 ($\mu g\ g^{-1}$, dry weight), of Pb, Ni, Zn, Fe and Mn, respectively. At 1600 m altitude, the values ranged between 0.225 to 0.534, 0.150 to 0.842, 0.234 to 0.905, 1.082 to 3.864 and 0.023 to 0.982 ($\mu g\ g^{-1}$, dry weight) of Pb, Ni, Zn, Fe, Pb and Mn, respectively. No Cd was detected at both altitudes.

Key words: FAAS, Honaz Dagi, plant, trace element.

Honaz Dağı-Denizli, Türkiye'de Yetişen Bitkilerde İz Element İçerikleri Üzerine Bir Çalışma

Özet

Denizli, Batı Anadolu'nun en hızlı gelişen kentlerinden biridir. Bu gelişimin çevreye etkilerinin araştırılması amacıyla Pb, Cd, Ni, Zn, Fe ve Mn ($\mu g\ g^{-1}$, kuru ağırlık) gibi iz elementlerin çevrede birikme oranının saptanabilmesi için 30 farklı bitki biyomonitör olarak kullanılmıştır. Örnekler, Honaz Dağı'nın Denizli şehrine bakan yakasından ve iki farklı yükseklikten toplanmıştır. Bitki örneklerinin alev atomik absorbsiyon spektrometresinde (FAAS) gerçekleştirilen ölçümleri sonucunda, belirtilen iz element konsantrasyonları saptanmıştır. Buna göre, 1000 m yükseklikten toplanan bitki örneklerindeki konsantrasyon değerleri; Pb için 0,273 ile 0,488 arasında; Ni için 0.099 ile 0.488 arasında; Zn için 0.306 ile 0.682 arasında; Fe için 1.017 ile 3.744 arasında ve Mn için 0.148 ile 0.674 ($\mu g\ g^{-1}$, kuru ağırlık) arasında saptanmıştır. 1600 m yükseklikten toplanan bitki örneklerindeki konsantrasyonlar ise Pb, Ni, Zn, Fe, Pb ve Mn için sırasıyla, 0.225 ile 0.534, 0.150 ile 0.842, 0.234 ile 0.905, 1.082 ile 3.864 ve 0.023 ile 0.982 ($\mu g\ g^{-1}$, kuru ağırlık) değerleri arasındadır. Her iki yükseklikten toplanan bitki örneklerinde de Cd'a rastlanmamıştır.

Anahtar Kelimeler: Bitki, FAAS, Honaz Dağı, iz element.

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INTRODUCTION

All compartments of the biosphere are polluted by a variety of inorganic and organic pollutants as a result of anthropogenic activities and alter the normal biogeochemical cycling. Among them, heavy metal contamination of the biosphere has increased sharply since 1900 and possesses major environmental and human health problems worldwide (Prasad and Freitas 2003). Although heavy metals are natural components of the environment, they are emitted into the environment in different ways; through natural sources such as continental dust, volcanic dust and gas, sea spray and biogenic particles or through anthropogenic inputs i.e. transportation, industry, fossil fuels, agriculture, and other anthropogenic activities (Aksoy et al. 2000). For most of the toxic trace metals, anthropogenic inputs are more important than natural sources. Man-induced mobilization of trace metals into the biosphere has become an important process in the global geochemical cycling of these elements. This effect is most evident in urban areas where several stationary and mobile sources (industrial activities, energy production,

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construction, urban waste treatment, vehicle exhausts) release large quantities of trace metals into the atmosphere, soil and aquatic ecosystems very often exceeding the natural emission rates (Samura et al. 2003).

Increasing anthropogenic influences on the environment, especially pollution loadings, have caused negative changes in natural ecosystems: decreased biodiversity, simplified structure, and lowered productivity. These degradation processes can be seen especially in forest ecosystems. Deterioration of forest health has been a major concern of the world for the past few decades (Shparyk and Parpan 2004). As such botanical materials have been used to detect the deposition, accumulation and distribution of trace metals in the ecosystems (Dogan et al. 2007). These provide the cheapest and simplest method for monitoring trace metals in the atmosphere.

A number of studies have been carried out alongside the urban and ruderal habitats in Turkey in this direction (Guleryuz et al. 2002, Baslar et al. 2003, 2005, Samura et al. 2003, Yilmaz and Zengin 2004, Yilmaz et al. 2006, Dogan et al. 2007, Cayir et al. 2008, Ozturk et al. 2008, Huseyinova at al. 2009). The samples collected in some of these studies have used mountainous areas as control group with the assumption that these are unpolluted (e.i. Baslar et al. 2003, 2005, Yilmaz and Zengin 2004, Dogan et al. 2007). Present investigation is important in terms of determining heavy metal levels in mountainous areas which are considered to be free of heavy metals and therefore taken as reference.

The aim of this study was to investigate the concentrations of Pb, Cd, Ni, Zn, Fe and Mn by using plant species from Honaz Dagi.

MATERIALS AND METHODS

Sampling Area

The study area Honaz Dagi is situated in the state of Denizli (Fig. 1). The peak of the mountain is 2571 m. It is the highest mountain in the Aegean Region. The state is fast developing as an industrial state mainly textile, marble and few others. It is on the most important highways and railways of the country. Rapid urbanization, increasing number of vehicles on the roads and industrialization are leading towards an increase in the pollution in this region. Currently, it is second in industrialization and population density, and first in farming activities in the West Anatolian part of Turkey.

The location of the sampling points on steep slopes provides results depending on altitude rather than on horizontal distance (Zechmeister 1995). The samples were collected from 1000 m and 1600 m above the sea level at a distance of 35-40 km away from the city center with a negligible traffic and pollution load.

Sample Collection and Preparation

The plants were collected from 1000 and 1600 m altitudes during July-August 2006. A total of 30 plant species were collected, 15 species from 1000 m and 15 species from 1600 m. The taxonomic determination of the plant samples was carried out according to Davis (1965-1985), Davis et al. (1988) and Guner et al. (2001).

About 200 g of aboveground parts of bushy species and well developed leaves of other plants were collected for analyses. The samples were dried in oven at 80°C for 24 h, milled in a micro-hammer cutter and fed through a 0.2 mm sieve. The samples were stored in clean self-sealing plastic bags under silica gel desiccant. Contamination from the micro-hammer cutter was negligible during the grinding because it was washed after every grinding, first with absolute alcohol then with distilled water.

Wet Digestion Procedure

The method used for plant digestion is described by Perkin Elmer Corporation (Anonymous 1996). The digested samples were aspirated into an air-acetylene flame and the metals determined by flame atomic absorption spectrometry (FAAS). The reproducibility of the method used in decomposing the leaf samples was checked by carrying out a triplicate analysis. All samples were analyzed immediately after digestion.

Reagents

All chemicals used were of analytical reagent grade unless otherwise specified. Triple distilled water was used throughout the experiments. Working metal standard solutions were prepared just before use, by diluting the stock standard solution with water.

Instrumentation

Determination of the metals was performed with Perkin Elmer Analyst 700 model flame atomic absorption spectrometer (FAAS) equipped with deuterium background correction, hollow cathode lamps (HCl) and acetylene burner. The absorption measurements of the metals were performed under the conditions recommended by the manufacturer.

Fig. 1. Geographical location of the study area.

A Cole-Parmer microfiltration apparatus with membrane filter (0.45 μm pore size manufactured by Micro Filtration Systems, MFS) was used for the filtration of the aqueous phase before metal determination.

RESULTS AND DISCUSSION

Various researchers have explained the sources for accumulation of some other trace elements. For example, Pb and Zn originate mainly from anthropogenic activities (Alfani et al. 2000, Blok 2005, Oliva and Rautio 2005). Major anthropogenic sources of Ni are burning of coal and oil, production of Cu, Ni and Pb, mining operations, steel works and cement industry (Nriagu and Pacyna 1988). Loppi et al. (1999) have reported that plants were highly affected from contamination of soil by Fe and Mn in the Mediterranean climate zone, although airborne Mn originates mainly from soil (Bargagli et al. 2003, Oliva and Rautio 2005), Fe originates both from anthropogenic and natural sources (Oliva and Rautio 2005).

It is important to take into consideration that in plants, the elements Fe, Zn, Mn and Ni are considered to be micronutrients essential for plant growth (Reid 2001, Stoponenicne et al. 2003). Enrichments of mostly lithogenic Ni and Zn in the top soil and corresponding depletions in the subsoil were often observed and explained as a result of nutrient cycling (Luster et al. 2006). Mn occurs in soils mainly in the form of compounds of Mn^{2+} and as oxide-Mn (Sanders 1983). Guevera et al. (1995) reported that there is a strong correlation between elements abundant in the soil and elements existing in plants and those elements in plants may stem from soil.

The analysis of the samples of 30 different plant species from two altitudes at Honaz Dagi showed that mean concentrations of Pb, Ni, Zn, Fe and Mn determined at 1000 m altitude ranged from 0.273 to 0.488, 0.099 to 0.488, 0.306 to 0.682, 1.017 to 3.744 and 0.148 to 0.674, (μg g^{-1}, dry weight) respectively (Table 1). On the other hand, at 1600 m altitude, the values of Pb, Ni, Zn, Fe and Mn ranged from 0.225 to 0.534, 0.150 to 0.842, 0.234 to 0.905, 1.082 to 3.864 and 0.023 to 0.982 (μg g^{-1}, dry weight) respectively (Table 2). Cd was not detected in the samples collected from both altitudes. According to the Osteras et al. (2000), Cd enters forest soils via atmospheric deposition, originating from burning of fossil fuels and mining activities and via spreading of

Table 1. Trace element contents in plants growing in the Mt. Honaz (μg g^{-1} dry weight) (1000 m).

Plants	Pb	Ni	Zn	Fe	Mn
Picnomon acarna (L.) Cass.	0.427	0.171	0.585	2.272	0.242
Papaver rhoeas L.	0.374	0.309	0.429	3.744	0.640
Melissa officinalis L.	0.434	0.182	0.522	3.584	0.404
Viscum album L.	0.384	0.123	0.575	1.920	0.228
Populus nigra L.	0.391	0.236	0.682	1.084	0.454
Pyrus communis L.	0.273	0.196	0.552	1.913	0.170
Salix alba L.	0.314	0.221	0.363	3.604	0.705
Juncus acutus L.	0.460	0.150	0.395	3.048	0.337
Euphorbia sp.	0.443	0.099	0.502	0.868	0.315
Quercus cocciferea L.	0.474	0.158	0.306	1.021	0.674
Quercus ithaburensis Decne. subsp. *macrolepis* (Kotschy) Hedge et Yalt.	0.488	0.488	0.522	1.071	0.567
Vitis sylvestris Gmelin.	0.407	0.154	0.372	1.017	0.334
Ficus caprificus L.	0.318	0.162	0.463	2.481	0.550
Rubus sanctus Schreber	0.358	0.154	0.321	2.215	0.563
Ulmus glabra Hudson	0.485	0.177	0.483	1.811	0.148
Min.:	0.273	0.099	0.306	0.868	0.148
Max.:	0.488	0.488	0.682	3.744	0.705
Mean:	0.40±0.02	0.20±0.02	0.47±0.03	2.11±0.26	0.42±0.05

Table 2. Trace element contents in plants growing in the Mt. Honaz (μg g^{-1} dry weight) (1600 m).

Plants	Pb	Ni	Zn	Fe	Mn
Onobrychis sp.	0.439	0.806	0.400	3.574	0.894
Alyssum corsicum Duby	0.473	0.842	0.800	3.840	0.982
Euphorbia macroclada Boiss.	0.534	0.650	0.894	2.486	0.182
Coronilla emerus L. subsp. *emeroides* (Boiss & Spnun) Uhrova	0.472	0.526	0.905	3.745	0.504
Juniperus oxycedrus L. subsp. *oxycedrus* L.	0.286	0.174	0.234	1.957	0.139
Pinus nigra Arn. subsp. *pallasiana* (Lamb) Holmboe.	0.225	0.165	0.806	1.141	0.023
Juniperus foetidissima Wild.	0.395	0.215	0.432	2.509	0.293
Rosa canina L.	0.398	0.150	0.347	1.082	0.426
Anthemis tinctoria L.	0.370	0.354	0.520	3.206	0.256
Populus tremula L.	0.510	0.331	0.736	1.299	0.424
Hordeum bulbosum L.	0.332	0.455	0.666	2.050	0.113
Aegilops umbellulata Zhuk.	0.346	0.745	0.485	3.864	0.523
Crataegus monogyna Jacq. subsp. *azorella* (Gris.) Franco	0.465	0.225	0.885	2.839	0.252
Pyrus amygdaliformis Vill. var. *lanceolata* Drop.	0.409	0.196	0.501	1.118	0.255
Berberis crataegina DC.	0.476	0.196	0.274	3.471	0.103
Min.:	0.225	0.150	0.234	1.118	0.023
Max.:	0.476	0.842	0.905	3.840	0.982
Mean:	0.41±0.02	0.40±0.06	0.59±0.06	2.55±0.27	0.36±0.07

lime and fertilizers, as such this could be the reason for our area because very little fossil fuels are used in this area, and traffic is negligible.

As can be seen from Table 1, in the plants collected from 1000 m, Ni was highest in *Quercus ithaburensis* subsp. *macrolepis* (0.488 μg g^{-1}), and lowest in *Euphorbia* sp. (0.099 μg g^{-1}), Zn was highest in *Populus nigra* (0.682 μg g^{-1}), lowest in *Quercus coccifera* (0.306 μg g^{-1}), Fe was highest in *Papaver rhoeas* (3.744 μg g^{-1}), lowest in *Euphorbia* sp. (0.868 μg g^{-1}), Pb highest in *Quercus ithaburensis* subsp. *macrolepis* (0.488 μg g^{-1}), and lowest in *Pyrus communis* (0.273 μg g^{-1}) and Mn highest in *Salix alba* (0.705 μg g^{-1}), lowest in *Ulmus glabra* (0,148 μg g^{-1}).

The results of analysis of trace element values in plants collected from 1600 m are presented in Table 2. The table shows that Ni is highest in *Alyssium corsicum* (0.842 μg g^{-1}), lowest in *Rosa canina* (0.150

μg g^{-1}), Zn highest in *Coronilla emerus* subsp. *emeroides* (0.905 μg g^{-1}), lowest in *Juniperus oxycedrus* subsp. *oxycedrus* (0.234 μg g^{-1}), Fe highest in *Alyssum corsicum* (3.840 μg g^{-1}), lowest in *Pyrus amygdaliformus* var. *lanceolata* (1.118 μg g^{-1}), Pb highest in *Berberis crataegina* (0.476 μg g^{-1}), lowest in *Pinus nigra* subsp. *pallasiana* (0.225 μg g^{-1}), and Mn highest in *Alyssum corsicum* (0.982 μg g^{-1}), lowest in *Pinus nigra* subsp. *pallasiana* (0.023 μg g^{-1}). A comparison of the minimum, maximum and average values reveals that Ni, Fe, Mn and Zn were higher at 1600 m altitude whereas Pb was slightly higher at 1000 m. When we compare our results with those of Dijingova et al. (1995), Baslar et al. (2003), (2005), Dogan et al. (2007) and Kapusta et al. (2006), Pb, Ni, Zn, Fe and Mn contents of plants collected by us from both altitudes were below the values published by these workers. Bowen (1979) has reported the normal natural concentration intervals for land plants as Cd: 0.2-2.4 μg g^{-1}, Ni: 1-5 μg g^{-1}, Zn: 20-400 μg g^{-1}, Fe: 70-700 μg g^{-1}, Pb: 1-13 μg g^{-1}, Mn: 20-700 μg g^{-1}. A comparison of our results with these findings (Table 1 and 2), clearly shows that our results are well below the accepted range. Therefore, the area is clean from the contamination of heavy metal pollution as regards the trace elements investigated by us. The level of accumulation we obtained in the plant sample is soil oriented.

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