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AVAILABILITY OF *MACLURA POMIFERA* (RAFIN.) SCHNEIDER AS A BIOMONITOR FOR THE HEAVY METAL POLLUTION

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Abstract

Heavy metal pollution usually results from traffic in the city centers. Because of its location Amasya expose to high traffic and atmospheric pollution. In this study, we examined the availability of the *Maclura pomifera* (Rafin.) Schneider for monitoring heavy metal pollution. In addition, heavy metal pollution of Amasya was evaluated. Leaf samples were collected from the *M. pomifera* individuals on the city street. Leaf samples were dried in drying oven at 70°C and then milled. Wet digestion method was applied to milled leaf samples. Heavy metal concentrations were measured by atomic absorption spectrofotometer. Leaf samples of *M. pomifera* contained much Fe than other elements. The concentrations of other elements, except Fe and Mn were also high. In this context, it may be said that *M. pomifera* can be used as a biomonitor for heavy metal pollution. Besides, there were Co, Cr, Ni and Pb pollution in Amasya city center.

The heavy metal contamination and pollution increased as the industry developed, and population rised. The factors that cause heavy metal contamination are factory and domestic wastes, exhaust gasses, mining, pesticides, fertilization etc. Plants take heavy metals from air and soil (Mertens *et al.* 2005). Some of the heavy metals are essential for plant growth, but in high concentrations they are toxic. High concentrations of heavy metals damage organisms and lead to decrease in crops production and causes chlorosis, necrosis, deformity in leaves and stem, defect in physiological processes such as protein synthesis, photosynthesis, respiration (Öktüren Asri and Sönmez 2006, Yıldırım *et al.* 2012). In order to keep the health of organisms and sustainability of ecosystems, it is required to determine and minimize pollution level.

In recent years, scientists usually use plants for monitoring heavy metal pollution (Mertens *et al.* 2005, Yıldırım *et al.* 2012). Biomonitoring is defined as using living organisms in order to determine environmental pollution. Plants are generally used as biomonitors, because plants cannot remove. Analysis of heavy metal concentrations in leaves is a useful tool for monitoring atmospheric pollution (Mertens *et al.* 2005). There are several studies about using plants as biomonitors for example, some agricultural plants such as *Triticum aestivum* L., *Brassica juncea* L., *Oryza sativa* L., and *Zea mays* L. (Karla *et al.* 2003), and some woody plants such as *Elaeagnus angustifolia* L., *Robinia pseudoacacia* L., *Platanus orientalis* L. and *Pinus brutia* Ten. (Aksoy *et al.* 2000, Çelik *et al.* 2005, Yıldırım *et al.* 2012).

In the current study, *Maclura pomifera* (Rafin.) Schneider, known as osage orange, was used as biomonitor in order to determine traffic-based heavy metal pollution in Amasya city center, Turkey. Leaf samples were collected in November 2011. Osage orange is used as ornemental plant in roadsides, parks and gardens extensively. A few studies were published about biosorption of osage orange (Pehlivan *et al.* 2012). No study can be found on heavy metal accumulation of this species. In this study it was aimed to determine the accumulation of selected heavy metals in *M. pomifera* and to examine the use of *M. pomifera* as biomonitor.

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Additionally the heavy metal accumulation in *Maclura pomifera* individuals growing in Amasya city center was investigated and heavy metal pollution level in the center was determined by using this species as biomonitor. Amasya is located in 40°39'8.5752" N and 35°49'43.7484" E, in the Middle Blacksea region of Turkey. Altitude is 411.69 m above the sea level. The city center is surrounded by high mountains and because of this air circulation is low, this situation cause atmospheric pollution.

Table 1. Mean concentrations and (±) standard deviation of the elements in the leaves of *Maclura pomifera* and the normal values of elements obtained from Kabata-Pendias and Pendias (2001), and Kabata-Pendias and Mukherjee (2007).

	Measured (µg/kg)	Normal (µg/kg)
Fe	60.03 ± 11.81	220 - 1200
Cu	20.97 ± 6.31	5 - 30
Mn	13.72 ± 5.16	30 - 300
Ni	8.89 ± 2.99	0.1 - 5
Pb	27.58 ± 12.43	5 - 10
Co	12.05 ± 4.62	0.02 - 1
Cr	21.35 ± 4.90	0.1 - 0.5

Table 2. Pearson correlation (R) and significance values (P) of the examined elements.

Maclura pomifera		Cu	Mn	Ni	Pb	Co
Fe	R	–0.239	0.368	0.895*	0.861	0.916*
	P	0.699	0.542	0.040	0.061	0.029
Cu	R		–0.989**	–0.011	–0.339	0.010
	P		0.001	0.986	0.577	0.987
Mn	R	0.443		0.120	0.428	0.105
	P	0.455		0.847	0.472	0.867
Ni	R	–0.011	–0.635		0.933*	0.997*
	P	0.986	0.249		0.020	0.000
Pb	R	–0.339	0.428	0.933*		0.912*
	P	0.577	0.472	0.020		0.031
Co	R	0.010	0.105	0.997*	0.912*	
	P	0.987	0.867	0.000	0.031	
Cr	R	0.079	0.016	0.962**	0.904*	0.942*
	P	0.899	0.980	0.009	0.035	0.016

* and ** indicate correlation is significant at 0.05 and 0.01% probability level, respectively.

Maclura pomifera, is a tree species belongs to Moraceae and because of its orange like fruits, it is known as osage orange (Smith and Perino 1981). This species is used as ornamental plant in parks, gardens and streets. Senescent leaves of *M. pomifera* were selected in order to determine the heavy metal accumulation in leaf litter. The leaf samples were collected from the *M. pomifera* trees growing along the streets in the city center and were dried in the drying oven at 70°C then grinded. The wet digestion (HNO_3 and HCl acid mixtures) was applied to the grinded leaf samples. The obtained solution was filtered and pure water was added to it. Pb, Cu, Ni, Co, Cr, Fe and Mn concentrations in the solution were measured by atomic absorbtion spectrofotometer (AAS). The statistical analyses were done by using SPSS (Version 15) program. In order to determine the relationships between the measured heavy metals, Pearson correlation analysis was applied to data set.

Heavy metal concentrations in *M. pomifera* leaves, measured in the current study, and normal values (Kabata-Pendias and Pendias 2001, Kabata-Pendias and Mukherjee 2007) obtained from the literature are shown in Table 1. Iron has the highest concentration and Ni has the lowest concentration. *Maclura pomifera* accumulated high amounts of Pb, Ni, Co and Cr. Concentrations of these elements were above the normal values (Kabata-Pendias and Mukherjee 2007). Copper concentration was within normal values (Kabata-Pendias and Mukherjee 2007). In this study, Pb was found in very high concentration. As the Amasya city center is exposed to high traffic pollution, Pb concentration may have been found very high in the leaf samples.

It is known that high concentrations of heavy metals are toxic to organisms and cause several damages. Kabata-Pendias and Mukherjee (2007) reported that Hg, Cu, Ni, Pb, Co, Cd, Ag, Be and Sn are the most toxic trace elements for plants. Heavy metals in high concentrations cause decrease of crops production and causes chlorosis, deformation and defect in some physiological mechanisms in plants, and defect in respiration, digestion, excretion and nervous systems in humans (Öktüren Asri and Sönmez 2006, Sossé *et. al.* 2004). According to Prasad and Hagemeyer (1999), especially Cu and Pb change permeability of cell membranes (Kabata-Pendias and Mukherjee 2007). In this context, high concentrations of heavy metals may lead to health risks in Amasya.

Any study on heavy metal accumulation in *M. pomifera* was not found. But there are several studies about heavy metal accumulation in other plant species (Aksoy *et al.* 2000, Yıldırım *et al.* 2012). Some of the plant species accumulate huge amounts of heavy metals such as *Brassica juncea* L. and *Thlaspi caerulescens* J & C Presl. and are called hyperaccumulators. Some of the others accumulate heavy metals and reflect the pollution status of the habitat called as biomonitors. Although in *M. pomifera* heavy metal accumulation is high, it is not enough to call the species as hyperaccumulator. It may reflects habitat status in terms of heavy metal pollution. *Maclura pomifera* has the most features of the biomonitor organism (Martin and Coughtrey 1982), such as measurable amount of heavy metal accumulation, easy sampling and attainability. So, this species may be used as biomonitor in heavy metal pollution. Concentrations of heavy metals in plants depend upon species, pollution status and other ecological conditions such as soil character. These features determine the heavy metal accumulation in plant tissues.

Results of correlation analysis were given in Table 2. Significant correlations were observed between the measured heavy metals. Arık and Yaldız (2010) reported similar relationships between elements. It is known that there are antagonistic and sinergistic reactions between elements. Presence of some elements interferes or facilitates the uptake of the other elements by plants. In *M. pomifera,* only the relation between Mn and Cu is antagonistic. Likewise, Yıldırım *et al.* (2012) also reported significant negative relation between Mn and Cu concentrations.

It was found that *M. pomifera* accumulated high amounts of Cu, Pb, Ni, Co and has the features to be used as biomonitor. So, this species may be used as a biomonitor for these elements.

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