PHYSICAL CHEMISTRY 2012

[11th] International Conference
on Fundamental and Applied Aspects of
Physical Chemistry

Under the auspices of the
University of Belgrade

Proceedings

The Conference is dedicated to
Professor Ivan Dragani**ć**

Septe**m**ber 24-28, 2012
B**e**lgrade, Ser**b**ia

K-30-P

PLANE (*Platanus acerifolia* Ait.) BARK AND TREE-RINGS AS BIO-INDICATORS

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Abstract

By analyzing metal content in bioindicators such as lichen, moss, fern, leaves etc., we can see an integral response to the pollution level in the region. Tree-ring analysis in contrast enables us to return to previous periods accurately and to understand trends of metal accumulation. Tree-rings and bark of plane (*Platanus acerifolia* Ait.) from Belgrade, Serbia was used as an indicator of environmental pollution. The Pb, Cd and Mn content in bark and tree-rings was determined by inductively coupled plasma atomic emission spectrometry (ICP-OES). A slight Pb concentration increasing trend in the plane tree-rings is observed in the entire period of investigation. A similar Cd and Mn concentration trand was noticed for plane tree-rings. Rough barks (linden) accumulate higher contents of the investigated elements than smooth barks (plane).

Introduction

The environment is under great influence from different sources. The use of vegetation provides the cheapest and simplest indicator for monitoring trace metal levels in the environment. Trees of temperate regions usually form visible annual growth rings, which can be dated accurately. It is therefore possible to collect wood samples of different age and analyze their heavy metals content in order to get a chronological record of trace elements pollution in the tree's environment [1, 2, 3].

The plane is a large deciduous tree growing to 20–35 m (exceptionally over 40 m) tall, with a trunk up to 3 m or more in circumference and it is a popular urban roadside tree. The bark is usually pale grey-green and smooth.

Experimental

We collected tree-rings and bark of plane (*Platanus acerifolia* Ait.) from the King Aleksandar Boulevard in 2010. In 2010 the reconstruction of the boulevard begins in about 2.5 km and the plane trees were cut. Two trees of similar size were selected (Latitude: 44º47′47″ N; longitude: 20º29′47″ E and latitude: 44º47′51″ N; longitude: 20º29′38″ E) for our purposes. Stem disks were taken from felled trees at breast height (1.3 m). For further analysis the disks were cut into segments with a stainless steel knife. Each plane core was divided into 3 year segments starting from 1935 to 2009.

Bark was taken as a separate sample from the stem disk. The content of elements in solution samples was determined by inductively coupled plasma atomic emission spectrometry (ICP-OES). ICP-OES measurement was performed using Thermo Scientific iCAP 6500 Duo ICP (Thermo Fisher Scientific, Cambridge, United Kingdom) spectrometer equipped with CID86 Charge Injector Device (CID) detector, standard glass concentric type nebulizer, quartz torch, and alumina injector. The optical system purged with argon and the Echelle polychromator thermostated at 38 ºC. The digestion was performed on an Advanced Microwave Digestion System (ETHOS 1, Milestone, Italy) using HPR-1000/10S high pressure segmented rotor. In the digestion, about 0.5 g of powdered tree-ring sample precisely weighed was mixed in each clean vessel with a mixture of 3 ml H_2SO_4 and 5 ml HNO_3 and then heated with microwave energy for 30 min. The temperature was controlled with a predetermined power program. After cooling and without filtration, the solution was diluted to a fixed volume of 25 ml for tree-rings and 50 ml for soils

Results and Discussion

Figure 1 shows the mean Pb, Cd and Mn concentrations in the plane tree-rings sampled from the King Aleksandar Boulevard.

From Figure 1(a) it can be noticed a slight increasing Pb concentrations trend in the plane tree-rings in almost the entire study period. Also we can observe two periods of low Pb concentrations dating from 1950 to 1964 and from 1989 to 2003. The highest Pb concentration in the plane tree-rings was measured in the period 1980/82.

The Cd concentration in the plane tree-rings (Figure 1(b)) indicates different changes of the concentration trends. From 1938 to 1961 it can be seen decreasing trend of Cd concentrations. The period from 1965 to 1994 can be roughly characterized as a period of small Cd fluctuations in the plane tree-rings. From 1994 to 2009 intense increase in the Cd concentration can be noticed. The maximum Cd concentration was measured in the period 1962/64.

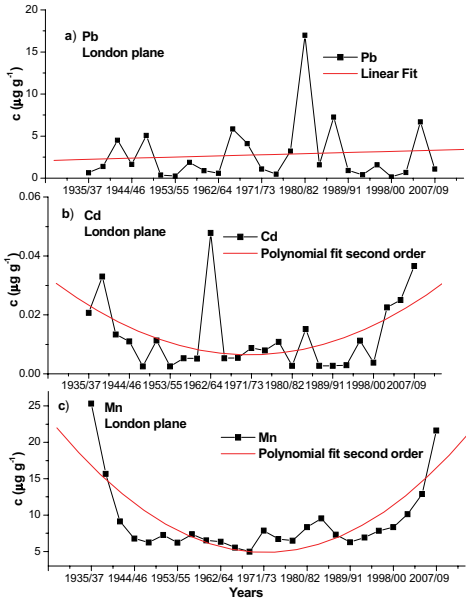

Figure 1. Mean Pb (a), Cd (b) and Mn (c) concentrations (µg g-1 dry weight) in plane (Platanus acerifolia Ait.) tree-rings at King Aleksandar Boulevard from 1935 to 2009.

Three characteristic periods, as in the case of Cd, we can observe for Mn (Figure 1(c)). The first period is the period of decreasing Mn concentrations in the

plane tree-rings dating from 1935 to 1949. The second period of nearly constant Mn concentrations is observed from 1949 to 1991, while the third dating from 1991 to 2009 is the period of constant Mn increase.

Table 1 shows average Pb, Cd and Mn concentrations in the bark and tree-rings of plane (our study) and Linden [4] as well as bark/wood ratio. Both species are deciduous trees. Bark can be used as an indicator of air pollution for different pollutants [5, 6]. Rough barks are known to accumulate metals more than smooth barks [7]. Linden bark is rough and for the plane it is smooth. From Table 1 it is noticeable that Pb and Mn concentrations in the linden bark where the higher than

Table 1. Average Pb, Cd and Mn concentrations (μg g^{-1}) in bark and tree-rings (wood) of plane [our study] and Linden [4] as well as bark/wood ratio.

Elements	London plane (Belgrade)		Bark/wood ratio	Linden (Obrenovac)		Bark/wood ratio
	bark	wood		bark	wood	
Pb	2.84	2.77	1.03	23.9	3.0	7.97
Cd	0.013	0.013	1.00	-	-	-
Mn	8.77	9.14	0.96	11.1	2.1	5.29

in the plane bark. By comparing the average concentrations of analyzed elements (Table 1) in the bark and tree-rings of plane and linden it can be seen that in the case of linden considerably higher concentrations were in their bark while in the case of plane approximately the same concentration are in the bark and tree-rings.

Conclusion

Slightly increased Pb concentration trend in the plane tree-rings has been seen in almost the entire period of investigation. The characteristic minimum concentration of Pb was obtained in the period from 1989 to 2003 and can be connected with the crisis of the nineties in our region. There was a similarity in the trend of change in concentration from 1935 to 2009 for Cd and Mn. In the linden bark (rough type bark) were found higher concentrations of analyzed elements than in the plane bark (smooth type bark).

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K-31-P

LARCH (*Larix europaea* Lam.) AND DOUGLAS-FIR (*Pseudotsuga menziesii* Mirb.) BARK AND TREE-RINGS AS BIO-INDICATORS

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Abstract

Tree-rings and bark of larch (*Larix europaea* Lam.) and Douglas-fir (*Pseudotsuga menziesii* Mirb.) from two locations in Serbia were used as indicators of environmental pollution. The Cd, Mn and Pb content in bark and tree-rings of larch and Douglas-fir were determined by inductively coupled plasma atomic emission spectrometry (ICP-OES). Average Cd, Mn and Pb concentrations were higher in the tree-rings of larch from the Avala location, while they were higher in Douglas-fir tree-rings for the REIK-Kolubara location. In almost all larch and Douglas-fir bark samples at both sites were measured higher concentrations of examined elements than in tree-rings.

Introduction

Dendrochemistry has emerged in recent years as a valuable tool enabling reconstruction of past pollution episodes. A basic assumption of dendrochemical studies is that the chemical make-up of the annual woody increment at least partly reflects the chemistry of the environment in which it was formed. Increased metal concentrations have been recorded in tree rings formed during periods of high industrial activity, increased urbanization and high traffic loads [1-4]. Douglas-fir is highly recommended species for dendrochemical studies [5].

Experimental

We collected tree-rings and bark of larch (*Larix europaea* Lam.) and Douglas-fir (*Pseudotsuga menziesii* Mirb.) from two locations in Serbia in March 2010. The first one is Avala and it is the mountain located 16 km south-east of Belgrade. Avala is a traditional picnic resort for Belgraders. The second location is REIK Kolubara. Douglas-fir and larch at the Kolubara location have been applied in our country for the rehabilitation by a forestation of the mechanically damaged land. Three larch and Douglas-fir trees of similar size were selected at each location. Stem disks were taken from felled trees at breast height (1.3 m). For further analysis the disks were cut into segments with a stainless steel knife. Each core was divided into 3 year segments starting from 1980 to 2009. Bark was taken as a separate sample from the stem disk. The content of elements in solution samples was determined by inductively coupled

plasma atomic emission spectrometry (ICP-OES). ICP-OES measurement was performed using Thermo Scientific iCAP 6500 Duo ICP (Thermo Fisher Scientific, Cambridge, United Kingdom) spectrometer equipped with CID86 Charge Injector Device (CID) detector, standard glass concentric type nebulizer, quartz torch, and alumina injector. The optical system purged with argon and the Echelle polychromator thermostated at 38 ºC. The digestion was performed on an Advanced Microwave Digestion System (ETHOS 1, Milestone, Italy) using HPR-1000/10S high pressure segmented rotor. In the digestion, about 0.5 g of powdered tree-ring sample precisely weighed was mixed in each clean vessel with a mixture of 3 ml H2SO4 and 5 ml HNO3 for tree-ring sample and then heated with microwave energy for 30 min. The temperature was controlled with a predetermined power program. After cooling and without filtration, the solution was diluted to a fixed volume of 25 ml.

Results and Discussion

Figure 1 shows the mean concentrations of Cd (a and b) and Mn (c and d) in larch and Douglas-fir tree-rings from 1980 to 2009 at the Avala and REIK-Kolubara locations. At Avala location (Figure 1(a)) it can be seen a similar Cd concentration trend change for the both examined tree species (larch and Douglas-fir). In the entire study period, mean Cd concentrations in tree-rings of larch and Douglas-fir have an increasing trend. Higher mean Cd concentrations were measured in the larch tree-rings than in tree-rings of Douglas fir in almost the entire study period at Avala location. Also at Avala location, as well as in the case of Cd, it can be seen similar behavior of Mn concentration trends in tree-rings of larch and Douglas-fir (Figure 1(c)).

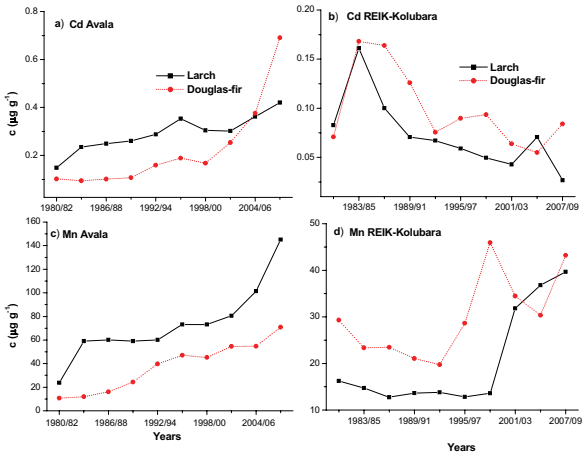

Figure 1. Mean Cd (a and b) and Mn (c and d) concentrations in larch and Douglas-fir tree-rings on Avala and REIK-Kolubara locations from 1980 to 2009.

Mean Cd concentrations measured in larch and Douglas-fir tree-rings from REIK-Kolubara location are shown on Figure 1(b). In this case also it can be noticed a good correlation between time trend changes of mean Cd tree-rings concentrations in larch and Douglas-fir. However, in this case after the maximum (1983/85) in almost all remain period mean Cd concentrations have a decreasing trend. In contrast to the Avala location at this location were measured higher mean

Cd concentrations in samples of Douglas fir. A similar trend of changes in mean Mn concentrations in larch and Douglas-fir tree-rings can be seen on a REIK-Kolubara location (Figure 1(d)). As in the case of Cd on REIK Kolubara location mean Mn concentrations are higher in Douglas fir tree-rings.

Average Cd, Mn and Pb concentrations in larch and Douglas-fir bark and tree-rings (wood) are shown in Table 1. For both locations in almost all samples higher concentrations of the examined elements are measured in the bark than in tree-rings. Bark accumulates pollutants straight from the atmosphere and they are deposited mainly on the surface. Bark can be roughly divided into living inner bark and dead outer bark [6]. The inner bark reflects the metal ion flow within a tree. Airborne pollutants are mainly accumulated in the outer bark. Element concentrations in the barks reflect concentrations both within the phloem and absorbed to bark predominately via wet and dry atmospheric deposition [7].

Table 1. Average Cd, Mn and Pb concentrations (μg g^{-1}) in bark and tree-rings (wood) of Larch and Douglas-fir from Avala and REIK-Kolubara locations.

Tree	Larch				Douglas-fir			
Locations	Avala		REIK-Kolubara		Avala		REIK-Kolubara	
Elements	bark	wood	bark	wood	bark	wood	bark	wood
Cd	0.75	0.29	0.16	0.07	1.12	0.22	0.60	0.10
Mn	176.2	73.6	154.2	20.6	144.8	37.5	208.9	30.0
Pb	2.46	2.71	1.80	0.37	1.72	1.20	0.91	0.88

Conclusion

Larch and Douglas fir tree-rings showed a similar Mn and Cd concentrations trends in both studied sites. Mean Cd and Mn concentrations in larch tree-rings were higher at the Avala location, while on-site REIK-Kolubara they are higher in Douglas-fir tree-rings. Higher Cd, Mn and Pb average concentrations in larch and Douglas-fir tree-rings were measured at the Avala location for both tree species.

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