



ANALYSIS OF *Cedrus atlantica* (ATLAS CEDAR) NEEDLES AS POTENTIAL PASSIVE SAMPLERS OF POLYCYCLIC AROMATIC HYDROCARBONS (PAHs) IN AIR

Tatjana Šolević Knudsen^{1,*}, Jelena Milić¹, Nenad Zarić², Ivan Gržetić³

¹University of Belgrade, Institute of Chemistry, Technology and Metallurgy, Njegoševa 12, 11000 Belgrade, Serbia

²University of Belgrade, Innovation Center of the Faculty of Technology and Metallurgy, Karnegijeva 4, 11000 Belgrade, Serbia

³University of Belgrade, Faculty of Chemistry, Studentski trg 12-16, 11000 Belgrade, Serbia

(* corresponding author: tsolevic@chem.bg.ac.rs)



INTRODUCTION

Cedrus atlantica (Atlas cedar) is an evergreen conifer that is common in cultivation as an ornamental tree in temperate climates. This decorative tree is very widespread in green areas in Belgrade, the capital of Serbia.

Considering the fact that needles of some coniferous tree species are capable of accumulating, in their cuticular wax layers, semi-volatile and low-volatile organic compounds from the air (Ratola et al. 2011), this study was carried out to determine whether or not *Cedrus atlantica* pine needles can accumulate atmospheric PAHs, and, therefore, if they can be used as passive samplers of these compounds.



EXPERIMENTAL

The needles of *Cedrus atlantica*, different in age, were collected in May 2016 in a city park in the city center of Belgrade. Presence of different PAHs in the air of Belgrade had already been confirmed by previous studies (Cvetković et al. 2015). In order to avoid possible erroneous conclusions that might be introduced by the sample preparation method, the samples were extracted using three different methods: ultrasonic extraction (Ratola et al. 2006), Soxhlet extraction (Ratola et al. 2006) and alkaline digestion followed by liquid-liquid extraction (Kelly et al. 2000). The extracts obtained by different methods were cleaned up and fractionated using column chromatography (Novaković et al. 2012).

All fractions isolated were analyzed by gas chromatography – mass spectrometry (GC-MS). The GC-MS analyses were focused on determination of presence or absence of the following compounds: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[j]fluoranthene, benzo[e]pyrene and benzo[a]pyrene, indeno[1,2,3-c,d]pyrene, benzo[g,h,i]perylene, dibenzo[a,h]anthracene. Additionally, methylated homologues of 2 – 4 ring PAHs were analyzed in the same way.

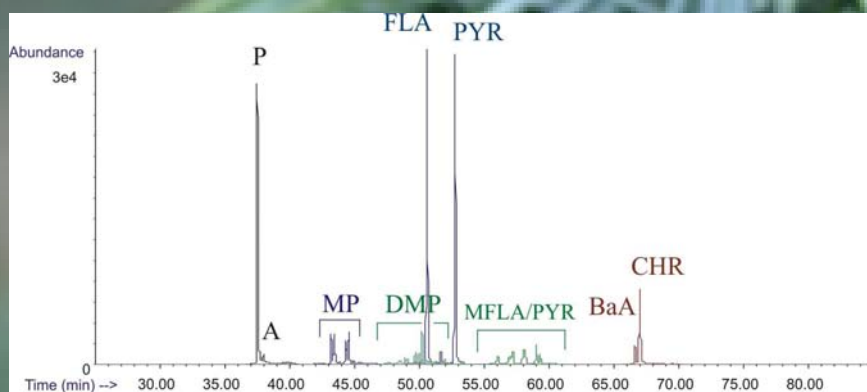


Figure 1. GC-MS chromatogram of ions $m/z = 178$ (phenanthrene – P and anthracene – A), $m/z = 192$ (methyl-phenanthrenes – MP), $m/z = 206$ (dimethyl-phenanthrenes – DMP), $m/z = 202$ (fluoranthene – FLA and pyrene – PYR), $m/z = 216$ (methyl-fluoranthenes and pyrenes – MFLA/PYR) and $m/z = 228$ (benzo[a]anthracene – BaA and chrysene – CHR) of the extract isolated from *Cedrus atlantica* needles.

RESULTS

The different sample preparation methods gave very similar results. Presence of 3 and 4 ring PAHs was confirmed in the extracts of the pine needles investigated (Figure 1). Moreover, presence of mono- and di-methyl homologues of 3 and 4 ring PAHs in these extracts was indicated as well (Figure 1).

CONCLUSIONS

The results of this research demonstrated that *Cedrus atlantica* pine needles are capable of accumulating 3 and 4 ring PAHs and their mono- and di-methyl homologues. Accordingly, it can be concluded that needles of this coniferous tree can be considered as passive samplers of these PAHs in the air.

REFERENCES:

- Cvetković A., Jovašević-Stojanović M., Marković D., Ristovski Z. (2015) Concentration and source identification of polycyclic aromatic hydrocarbons in the metropolitan area of Belgrade, Serbia. *Atmospheric Environment* 112, 335-343.
- Kelly C.A., Law R.J., Emerson H.S. (2000) Methods for analysis for hydrocarbons (PAH) in marine samples. *Aquatic environment protection analytical methods* Number 12.
- Novaković M., Ali Ramadan M.M., Šolević Knudsen T., Antić M., Beškoski V., Gojčić-Cvijović G., Vrić M.M., Jovančićević B. (2012) Degradation of methyl-phenanthrene isomers during bioremediation of soil contaminated by residual fuel oil. *Environmental Chemistry Letters* 10, 287-294.
- Ratola N., Lacorte S., Alves A., Barcelo D. (2006) Analysis of polycyclic aromatic hydrocarbons in pine needles by gas chromatography–mass spectrometry–comparison of different extraction and clean-up procedures. *Journal of Chromatography A* 1114, 198–204.
- Ratola N., Amigo J.M., Oliveira M.S.N., Araújo R., Silva J.A., Alves A. (2011) Differences between *Pinus pinaster* and *Pinus pinaster* as bioindicators of polycyclic aromatic hydrocarbons. *Environmental and Experimental Botany* 72, 339–347.

ACKNOWLEDGMENTS:

We thank the Ministry of Education, Science and Technological Development of the Republic of Serbia (Projects 176006 and III 43004) for supporting this research.