Proposition of PhD thesis

The assessment of urban air pollution by environmental analytical methods

Edina Fehérné Baranyai

Supervisor: Dr. József Posta, professor

UNIVERSITY OF DEBRECEN
PhD Program in Chemistry
Debrecen, 2015

I. INTRODUCTION AND AIM OF WORK

The rapid urbanization and industrialization in the last decades resulted in the significant emission of pollutants that causes negative effects on the urban population, the built environment as well as the terrestrial and aquatic ecosystem. Urbanization results in the deposition of pollutants and other toxic substances causing the degradation of environmental conditions

Recent study focuses on urban particulate matter with natural and anthropogenic origin, which may have severe health effects. Dust emitted to the atmosphere in urban environment is mainly caused by traffic, originating from the burning fuel. Significant amount of solid particle can reach the atmosphere by household private heating, as well as it consists of natural and human related particles transported by wind and moisture. The symptoms developed in human body is dependent on the physical and chemical characteristics of the particles as well as the inhaled amount. Different substances can be adsorbed on the surface of particles which may cause adverse health effects.

The bottleneck of urban dust research is usually the collection of samples, since the conventional sampling procedures usually do not provide enough sample for the complex physical, chemical and morphological analysis. The sampling process usually takes place at one location and the collected particles carry momentary information about the pollution load. The aim of our research is to find new sample collecting methods for the complex environmental analytical investigation of urban dust that are different than the well-known particulate matter monitoring systems. Our aim was to analyse the qualitative and quantitative characteristics of dust load affecting an urban environment on a smaller and larger time scale.

The lower the average diameter of dust particles is, the lower it reaches the lung that highlights the importance of fractionated sampling. The gas turbines of combined cyclic power plants of Debrecen and Nyíregyháza (DKCE and NYKCE) are protected from the corrosive effect of solid particles

by a two-step filter system. The filter system of power plants provide fractionated sampling: on the coarse filters particles with diameter above 10 μm are trapped, fine filters collect particles between 1 μm and 10 μm, while solid particles with the average diameter under 1 μm access the turbine area. Our aim was to collect and analyse the physical, chemical and morphological characteristics of the solid particles collected by the coarse and fine filters, as well as in the turbine area. The relatively high amount of sample enables the study of rarely analysed components, such as antimony species or platinum metals. We wanted to investigate the water soluble anion and cation content, elemental concentration, thermal stability, organic matter and pollen concentration of the collected dust as well as the chemical composition of individual particles.

The aim of recent study was also to investigate a dust collection method, which provides information about the dust load of a typical city integrated on a larger region. Tree leaves are sensitive and highly exposed to air pollution thus can be used to assess the air quality of urban environment. Leaves can trap various airborne particles such as trace elements, pollens, spores and salts. The capacity of leaves as dust traps depends on such factors as surface geometry, phyllotaxy, epidermal and cuticular features, leaf pubescence, and height and canopy of trees. They could absorb gaseous pollutants via their stomata which interact between plants and their environment; in this aspect leaves are active air contaminant collectors. On the other hand, leaves collect and deposit dust via their trichomes; thus they can also be used as passive dust traps in assessment studies. Therefore, the purpose of this study was to analyse the amount of dust and the elemental concentration of air contaminants in the deposited dust (Ba, Cu, Fe, Mn, Ni, Pb, S, Sr and Zn) along an urbanization gradient. By scanning electron microscopy (SEM) analysis we explored the interaction between morphological and anatomical parameters as well as the dust trapping and air contaminant accumulation capability of leaves.

It was also planned to study if tree leaves can be used as bio indicators to assess a short term anthropogenic air pollution. Explosive pyrotechnic

devices are widely used for celebrating specific events causing an unusual environmental effect on the ambient air quality. They are most frequently used in the already polluted urban areas, emitting additional amount of metal particles, gases, and various organic compounds which can cause a temporary decrease in air quality. The environmental aspects of fireworks shows are usually studied by analysing the concentration and composition of airborne particulate matter (PM10 and PM2.5) collected with conventional sampling methods. Since leaf sampling is widely used in pollution studies due to the inherent variability in crowns, our aim was to investigate the applicability of this dust sampling for the analysis of deposited dust load and trace element emission (Al, As, Ba, B, Ca, Cu, Fe, K, Mg, Mn, Na, P, S, Zn, Li és Sr) by a fireworks event organized on the 20th of August in Debrecen.

II. EXPERIMENTAL METHODS

The DKCE power station of Debrecen protects its turbines from the corrosion of solid particles with a complex filter system that consists of 180 coarse and 180 fine filters. In 8-9 months of operation the air is continuously sucked through the filters, which means nearly 5000 working hours and the total volume of flowing air is 2.8 billion m^3. The sample collection takes place continuously at a 8-12 m altitude. After the operating period the filters are removed while the turbine area is washed by a liquid detergent.

Dust particles collected from the coarse filters were removed and further fractionated by an electric sieve (Ilmvac THYR2). The sample preparation prior to the elemental analysis was carried out by microwave assisted wet digestion (MLS mega 1200, Milestone), as well as by water extraction in an ultrasonic bath (Transsonic 460/H). The elemental analysis of dust particles originating from the coarse and fine filters as well as from the turbine area (the liquid detergent) was carried out by inductively coupled plasma optical emission spectrometry (ICP-OES, IRIS Intrepid II XDuo,

Thermo Fisher Scientific), while the platinum metals and antimony were determined by graphite furnace atomic absorption spectrometry (GFAAS, Perkin Elmer AAnylist 600). For anion analysis ion chromatography was used (Metrohm 719 VA). Thermoanalytical investigations were carried out by a MOM-Derivatograph-C type of instrument which is coupled by an ATOMKI QGA-D mass spectrometer that enables the identification of gases and burning products. The reflexive studies were carried out with HITACHI S-4300 electron microscope, for the quantitative determination BRUKER QUANTAX 400 energy dispersive x-ray spectrometer was applied. The chemical composition of individual particles were studied by electron probe microanalysis (EPMA). Transmission pictures were taken with JEOL 2000 FX-II transmission electron-microscope equipped with Oxford Link-Isis energy dispersive X-ray spectrometer. The average size distribution of particles collected from the washing detergent of the turbine area was investigated by dynamic light scattering photometry (Brookhaven Research System). The pollen concentration of samples was determined by an OLYMPUS CX 41 optical microscope with 600 times exaggeration. The polycyclic aromatic hydrocarbons (PAH) and polychlorinated biphenyl (PCB) compounds were analysed according to MSZ ISO 12884 by gas chromatography mass spectrometry (GCMS-QP 2010 Plus, Schimadzu).

For the investigation of urban air pollution using tree leaves the sampling areas were located in and around the city of Debrecen (Hungary). Along an urbanization gradient three sampling areas were chosen representing a decreasing level of urbanization (urban, suburban and rural). Within each sampling area four sites were selected and 3 tree individuals were chosen randomly in each site. Leaf sampling was carried out in August 2010. Leaves of *Padus serotina*, *Acer campestre*, *Acer negundo*, *Quercus robur* and *Celtis occidentalis* were collected in plastic bags and they were stored at +4 °C in the dark for analysis.

We used a flatbed scanner to determine the surface area of leaves. The deposited dust was washed down from leaves and after drying were wet

digested at atmospheric pressure. The leaves were dried, homogenized and digested in a microwave assisted system. The concentration of Ba, Cu, Fe, Mn, Ni, Pb, S, Sr and Zn in deposited dust as well as in leaves was determined by ICP-OES. Scanning electron microscopy (SEM) was used to investigate the surface of leaves as well as the size and density of the stomata of the species.

For the assessment of a real anthropogenic effect silver linden (*Tilia tomentosa*) leaves were chosen since the morphology, canopy structure, and the dust preserving epicuticular wax on the leaf surface make linden trees ideal for bio monitoring studies. These trees are widespread in and around the city of Debrecen and can be easily distinguished from other species. We collected the control samples 2 days before the festivities (18th and 19th of August, 2011) from the individual selected species; the trees were marked and their coordinates were registered. Sample collection from the same 41 individuals was repeated 2 days after the fireworks show (21st and 22nd of August, 2011). Samples were collected in paper bags, and they were stored at +4 °C for analysis. The surface area of leaves was determined by a flat scanner. The foliar dust particles were washed down and wet digested on atmospheric pressure. The determination of Al, As, Ba, B, Ca, Cu, Fe, K, Mg, Mn, Na, P, S, and Zn was carried out by ICP-OES, while the concentration of Li and Sr was determined by microwave plasma atomic emission spectrometry (MP-AES 4100, Agilent Technologies).

Statistical calculations were performed using the SPSS/PC+ and Canoco for Windows 4.5 statistical software packages. The normal distribution was tested with a Shapiro–Wilk test. The homogeneity of variances was tested with Levene's test. Two-way analysis of variances (ANOVA), one sample t-test, principal component analysis (PCA) and redundancy analysis (RDA) were applied. Significant differences were evaluated by Tukey and LSD tests.

III. NEW SCIENTIFIC RESULTS

1. Filter system of combined cyclic power plants as a new tool for urban dust analysis

The two-step filter systems applied by combined cyclic power plants continuously collect solid particles under stable conditions. Comprehensive study of urban dust requires a relatively large amount of sample thus our results are a new approach of air pollution assessment from both environmental and sanitation point of view.

1.1 Sampling and sample pre-treatment methods are developed for the elemental analysis of the dust particles trapped by the filter systems as well as collected in the turbine area. It was verified that metal salts have a determined particle size depending on their crystalline structure and origin.

According to our results no significant difference occurred between the Ca, Mg, Cr, Ni and Al concentration of the different fractions. The level of Fe and Zn elevated in larger particles collected by the coarse filters, while the concentration of Na, K and S increased in smaller particles trapped by the fine filters. The concentration of Mn was under the limit of detection in dust samples gained from the turbine area, thus its compounds form particles with smaller average diameter. The level of lead was significantly elevated in dust samples originating from the fine fraction.

1.2 We determined the morphology, size, shape, heterogeneity and chemical composition of individual particles.

Several particles originating from coarse and fine fractions contained Zn, Fe and Cu in higher concentration while unusually high carbon signals in EDS spectra suggest the elevated amount of carbon containing substances in dust samples. In some particles similarly high carbon, oxygen and silicon content was determined and many titanium dioxide, iron oxide, pollen, soot, calcium sulphate and silicon dioxide particles were identified.

The average size distribution of particles suspended in the washing solution of the turbine area proved to be bimodal, with a lower peak (under 200 nm) of primary particles and a higher peak of aggregates. It was stated that this solution with the dust particles accessing to the turbine area is a nanoparticle containing homodisperse suspension which may carry important information considering human health.

1.3 It was determined that the pH of the water extracted solution of dust samples is near neutral (pH=6.45), while the extractable substances are mainly inorganic metal salts, that are soluble in the form of chloride, nitrate and sulphite. Methods have been developed for the platinum metal analysis of dust. The concentration of rarely investigated substances have also been studied as polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), as well as antimony trioxide and antimony trisulphide.

The relatively high volume of collected dust enabled the analysis of elements which concentration is hard to be determined from samples collected by the conventional sampling methods. Among the platinum metals rhodium and palladium was found in both DKCE and NYKCE samples, while platinum was not detected. From the antimony species the concentration of antimony trioxide proved to be higher in samples compared to antimony trisulphide and the results show similarity between the two studied cities. Both the level of

platinum metals and antimony were under the regulated limit in all studied regions and years. From the polycyclic aromatic hydrocarbons fenantren, fluoranthene and pyrene were present in the collected dust particles of both cities, while in the particles originating from the city of Debrecen, benzo(a)anthracene was also detected. None of the samples contained polychlorinated biphenyl compounds.

1.4 Based on thermoanalytical studies the thermal stability of dust samples were evaluated as well as the ratio of carbon containing substances were determined (such as organic material and soot). According to pollen analysis the total pollen concentration of dust was established as well as the dominant species were compared between the two cities.

Based on thermoanalytical studies the thermal stability of dust samples can be evaluated as well as the ratio of carbon containing substances can be estimated (such as organic material and soot). According to the thermoderivatographic analysis, the mass decrease of dust samples in air atmosphere is 37.5 mass percent, which can be partially caused by the loss of moisture and crystalline water content of inorganic substances present in dust. The mass decrease in nitrogen atmosphere proved to be lower (23% m/m). This phenomena can not only be explained by the loss of moisture and crystalline water content of some compounds, but also can be interpreted by the loss of volatile and less volatile substances.

Thermoanalytical studies proved that dust samples contain a significant amount of organic substances and pollen particles were also identified in SEM images (figure 1). The dust trapped on the filter system were analysed for pollen concentration and also the dominant species were determined and compared. According to our results-due to the relatively high average size of the pollen particles-they are captured mainly by the coarse filters since they were only rarely present in the scanning electron microscopic images of the

fine fraction. The total pollen concentration of dust samples collected in Debrecen were near 2 million/g, which is three times higher than the pollen concentration of the samples from Nyíregyhaza. The dominant species in both cities were the same, which all cause allergic symptoms except oak and acacia.

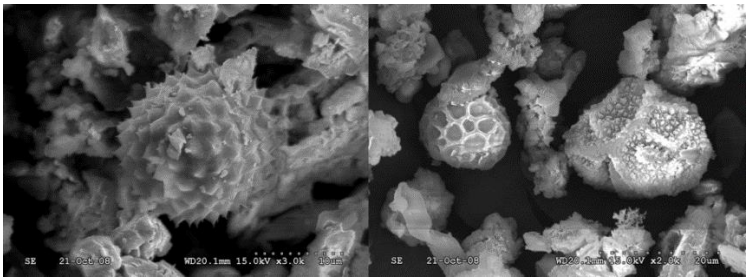

Figure 1: SEM images of pollen particles

2. Tree leaves as biological dust traps for air pollution assessment

The application of tree leaves for the assessment of air pollution integrated on a larger region of a city was investigated along an urbanization gradient. We studied the dust collecting and air pollutant accumulation capability of trees commonly planted in urban parks. It was demonstrated that the application of tree leaves for the assessment of air contamination is highly dependent on the morphological and anatomical parameters of leaves.

2.1 It was determined that the highest dust amount was trapped on the surface of leaves of *Acer negundo* and *Celtis occidentalis* thus these are the most suitable among the studied species to be applied for the monitoring of urban dust.

Based on the statistical results the five investigated tree species had a significant effect ($F_{14.45}=64.662$, $p<0.001$) on the foliage dust trapped by the surface of the leaves. The highest amount of solid particles were measured on the leaves of *Acer negundo* and *Celtis occidentalis*, which is proved by the higher amount of trichomes observed on the SEM images (figure 2) in case of these two species. The smallest amount of dust was collected on the leaf surface of *Padus serotina* and *Quercus robur* due to their less structured morphology.

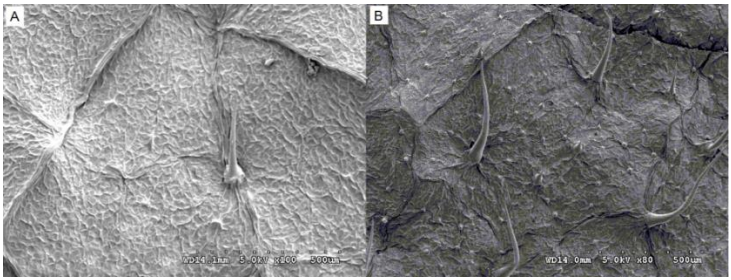

Figure 2: SEM images of leaf surface
(A: *Acer negundo*; B: *Celtis occidentalis)*

We found that the leaves' surface of *Acer negundo* and *Celtis occidentalis* is covered by a large number of trichomes, which made them especially suitable to decrease the level of air pollution.

2.2 It was stated by the elemental analytical results of the leaf samples that *Acer negundo, Quercus robur* and *Celtis occidentalis* accumulated the air contaminants in the highest concentration. Thus these species are the most suitable among the studied ones for the assessment of urban air contamination.

PCA showed a total separation of species based on the elemental concentration of leaf samples and foliage dust (figure 3). The concentration of

elements was the highest in the leaves of *Acer negundo, Quercus robur* and *Celtis occidentalis,* which is explained by the diverse size and high amount of stomatas. Our study demonstrated that *Acer negundo, Celtis occidentalis* and *Quercus robur* were useful biological indicators because of their large stomata size and high stomata density. Our results show that the stomata size and density were also important in dust deposition.

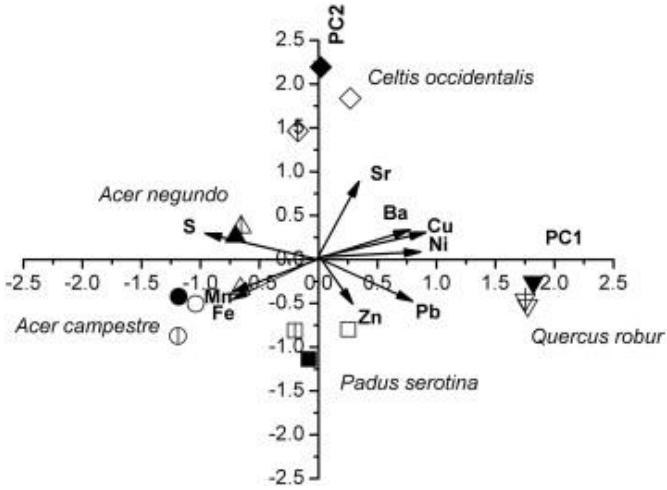

Figure 3: The principle component analysis of elemental concentration results (PC1: 80,2 %, PC2: 7,7 %)

3. Application of tree leaves for the assessment of a relevant anthropogenic effect

The short term negative effect of an anthropogenic activity was also studied. The fireworks show in Debrecen resulted in a higher amount of dust particles deposited on the surface of tree leaves. Our findings suggest that the relatively high altitude of detonations allow the chemicals to disperse in the fine and ultrafine fractions.

3.1 Based on the measured foliage dust it is stated that fireworks show resulted in an elevated solid particle emission.

Significant increase ($p<0.05$) of dust amount was found before and after the fireworks show (figure 4).

The foliage dust significantly increased based on the GLM results after the fireworks event in all studied areas except the Southwestern region of the city, where the amount of dust was significantly lower after the event. According to the statistical evaluation of data both the sampling period (before and after the fireworks event) and sampling sites (center, SW, SE NW, NE) had a significant effect on the foliage dust ($p<0.05$). The highest dust load occurred in the Northwestern part of the city.

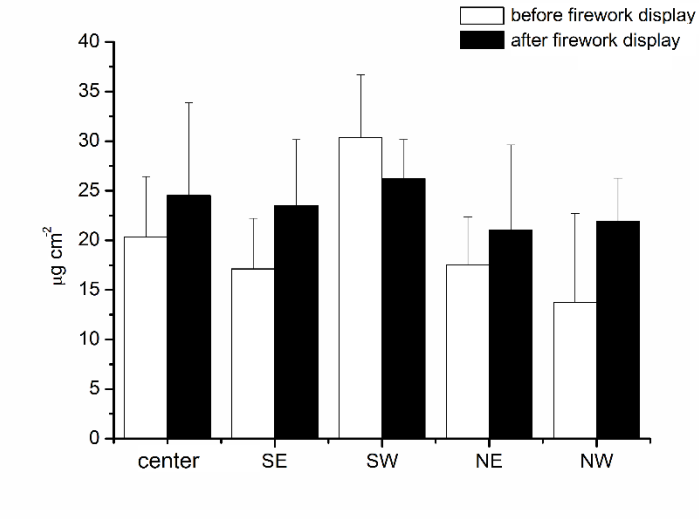

Figure 4: Amount of dust on tree leaves before and after the fireworks display considering the sampling sites
(center: city center, SE: southeastern, SE: southwestern, NE: northeastern, NW: northwestern

3.2 The elemental concentration of foliage dust did not elevate significantly after the fireworks display suggesting that due to the relatively high altitude of detonations the particles disperse in the finer fractions.

Our results proved that the concentration of Ca, Mg, and Sr statistically increased in the centrum, Southwestern, Northeastern and Northwestern sampling areas, respectively ($p<0.05$). A higher level of Al, Ba, B, Cu, Mn, Li, Na, and P was also observed in the centrum, Southwestern, Northeastern, and Northwestern sampling areas, although the difference was not significant. Pyrotechnic detonations therefore cause environmental risk by the elevated amount of dust deposition but do not contribute significantly to the background concentration of toxic metals in foliage dust.

According to PCA positive correlation was observed with PC1 in case of Zn, Ba and Al while K, B and Li correlated negatively with the same axis. Positive correlation was found with PC2 by the concentration of Cu, Fe, Mn, Mg and Ca, while negative by Sr and As (figure 5).

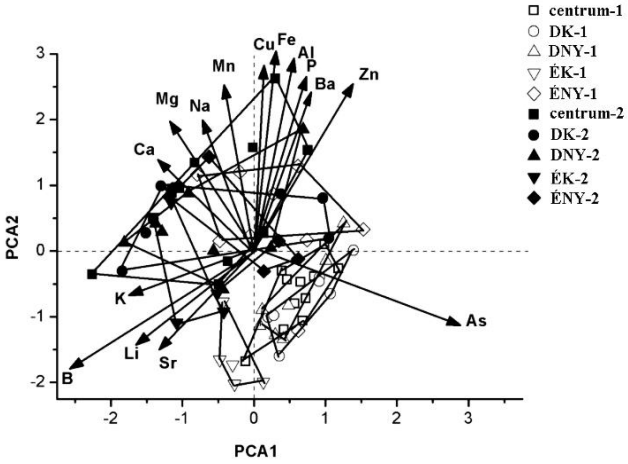

Figure 5: Principle component analysis of elements measured in foliage dust (1-before fireworks display; 2- after fireworks display; PC1: 32,9%; PC2: 26,1%)

IV. POSSIBLE APPLICATION OF THE RESULTS

Particulate matter is considered as an abiotic indicator which provides information about the quality and quantity of air pollutants emitted to the atmosphere. Its representative collection as well as complex chemical and morphological analysis carry useful information about the urban environment and health of its population.

For the safe operation, in combined cyclic power plants filter systems are applied to eliminate the solid particles from the continuous air flow. After the operation time of 9 months, both the coarse and glass filters are replaced and disposed as hazardous waste. In recent study it was highlighted, that the particulate matter trapped by the filters can be used to assess the air quality of a typical urban area. Due to the location of these power plants the analysis results represent the pollution load of a typical urban environment integrated for a longer period of time. The filter system enables fractionated sample collection thus the separate investigation of solid particles with different size. Our results can contribute to studies considering the effect of urbanization as well as to epidemiological assessments.

In recent study it was also demonstrated, that the application of tree leaves for the assessment of air contamination is highly dependent on the morphological and anatomical parameters of leaves. By scanning electron microscopy (SEM) analysis we explored the interaction between morphological and anatomical parameters as well as the dust trapping and air contaminant accumulation capability of leaves. Our study demonstrated that *Acer negundo*, *Celtis occidentalis* and *Quercus robur* were useful biological indicators because of their large stomata size and high stomata density. We found that the leaves' surface of *Acer negundo* and *Celtis occidentalis* is covered by a large number of trichomes, which made them especially suitable to decrease the level of air pollution. Our results show that the density of trichome, stomata size and density were important in dust deposition. Leaves with a high trichome density can deposit a larger amount of dust, so these tree

species may decrease the amount of solid particles from air in urban and contaminated areas.

The short term negative effect of an anthropogenic activity was also studied. The fireworks show in Debrecen resulted in a higher amount of dust particles deposited on the surface of tree leaves. Our findings suggest that the relatively high altitude of detonations allow the chemicals to disperse in the fine and ultrafine fractions. Thus, emitted pollutants by fireworks displays did not elevate the concentration levels of elements in deposited dust since the background concentration of these inorganic components in heavy dust is already high in polluted cities like Debrecen. Pyrotechnic detonations therefore cause environmental risk by the elevated amount of dust deposition but do not contribute significantly to the background concentration of toxic metals in foliage dust. The environmental effects of fireworks shows are quite controversial, our results may contribute to further investigations.

V. PUBLICATIONS

Articles connected to the thesis

Published/Accepted articles

1. Edina Baranyai, Edina Simon, Mihály Braun, Béla Tóthmérész, József Posta, István Fábián: The effect of a fireworks event on the amount and elemental concentration of deposited dust collected in the city of Debrecen, Hungary *Air Quality, Atmosphere and Health* (2015) DOI 10.1007/s11869-014-0290-7 IF (2014): 1,804

2. Edina Simon, Edina Baranyai, Mihály Braun, Csaba Cserháti, István Fábián, Béla Tóthmérész: Elemental concentrations in deposited dust on leaves along an urbanization gradient. *Science of the Total Environment*, 490 (2014) 514-520. IF (2104): 4,099

3. Edina Baranyai, Dávid Nagy, Imre Tóth, József Posta: The environmental and morphologycal analysis of urban dust. *Studia Universitatis "Vasile Goldis", Seria Stiintele Vietii*, 21 (2012) 71-75.

4. Baranyai Edina: Tölgyerdő, kertvárosi erdőterület és városi park fáinak levelén kiülepedett por és a levelek elemtartalmának vizsgálata. *Természetvédelmi Közlemények*, 18 (2012) 45-57.

Not published articles

5. Edina Baranyai, Dávid Nagy, Edina Simon, Mihály Braun, József Posta: The filter system of power plants – a new tool in air quality assessment *Air Quality, Atmosphere and Health* (ready for publication)

Proceedings in conference book

6. Baranyai Edina, Simon Edina, Braun Mihály, Posta József, Tóthmérész Béla, Fábián István: Tűzijáték hatásának vizsgálata a falevelekre ülepedő városi por elemösszetételére. *X. Kárpát-medencei Környezettudományi Konferencia* (2014) 11-16.

Articles not connected to the thesis

Published/Accepted articles

7. Edina Simon, Sándor Harangi, Edina Baranyai, Mihály Braun, István Fábián, Szabolcs Mizser, Leila Nagy, Béla Tóthmérész: Distribution of toxic elements between biotic and abiotic components of terrestrial ecosystem along an urbanization gradient: soil, leaf litter and ground beetles. *Ecological Indicators* (accepted for publication) IF(2014): 3,444

8. Andrea Nagy, Edina Baranyai, Attila Gáspár: Interfacing microfluidic chip based chromatography with flame atomic absorption spectrometry for the determination of chromium (VI). *Microchemical Journal* 114 (2014) 216-222. IF (2014): 2,746

9. Ildiko Bodnar, Andrea Szabolcsik, Edina Baranyai, Andrea Uveges, Norbert Boros: Qualitative characterization of household greywater in the northern great plain region of Hungary. *Environmental Engineering and Management Journal* 13 (2014) 2717-2724. IF (2014): 1,065

10. Milán Fehér, Edina Baranyai, Edina Simon, Péter Bársony, István Szűcs, József Posta, László Stündl: The interactive effect of cobalt in *Artemia* on the survival and larval growth of barramundi, *Lates calcarifer*. *Aquaculture*, 414–415 (2013) 92–99. IF (2013): 1,608

11. Edina Simon, Edina Baranyai, Mihály Braun, István Fábián, Béla Tóthmérész: Elemental concentration in mealworm beetle (*Tenebrio molitor L.*) during metamorphosis. *Biological Trace Element Research* 154 (2013) 81-87. IF (2013): 1,923

12. Türk Gábor, Balázs Boglárka, Harangi Sándor, Fehérné Baranyai Edina, Gyulai István, Szabó Szilárd: A vízminőség vizsgálata egy Felső-Tisza menti holtmedren. *Hidrológiai Közlöny* 94 (2014) 41-46.

13. Málnás Kristóf, Harangi Sándor, Balogh Zsuzsanna, Baranyai Edina, Braun Mihály, Dévai György, Simon Edina: Nehézfém analitikai vizsgálatok a Felső-Tisza és Szamos folyó hazai szakaszán. *Hidrológiai Közlöny* 94 (2014) 62-65.

14. Fehér Milán, Baranyai Edina, Bársony Péter, Simon Edina, Posta József, Stündl László: A kobalt-klorid hatása a barramundi lárva (*Lates calcarifer*) termelési paramétereire és egyöntetűségére. *Acta Agrariensis Debreceniensis* 51 (2013) 21-25.

15. Fehér Milán, Bársony Péter, Baranyai Edina, Posta József, Stündl László: Kedvező biológiai hatású mikroelemekkel dúsított Artemia alkalmazása a barramundi (*Lates calcarifer*) lárvanevelésében. *Acta Agrariensis Debreceniensis* 48 (2012) 11-16.

Not published articles

16. Edina Simon, Sándor Harangi, Edina Baranyai, István Fábián, Béla Tóthmérész: Assessment of impact of anthropogenic activities and urbanization on trace element concentration in deposited dust and tree leaves. *Environmental Geochemistry and Health* (under review) IF (2014): 2.573

Book chapter

17. Bodnár Ildikó, Szabolcsik Andrea, Baranyai Edina, Boros Norbert, Fórián Sándor: Épületek csapadékvizeinek és szürkevizeinek vizsgálata az Észak-Alföldi régióban környezetbarát és energiahatékony hasznosítás céljából. Fenntartható energetika, megújuló energiaforrások optimalizált integrálásával, Akadémiai Kiadó, 5. fejezet, 167-201. (ISBN 9789630595407)

Conference lectures (L) and posters (P) connected to the thesis

International conferences

18. Edina Baranyai, Edina Simon, Mihály Braun, Béla Tóthmérész, István Fábián: The effect of firework on the elemental concentration of dust deposited on tree leaves. *International Conference on Atmospheric Dust*, June 1-6. 2014., Bari, Italy (L)

19. Edina Simon, Edina Baranyai, Mihály Braun, Csaba Cserháti, István Fábián, Béla Tóthmérész: Assessment of air contaminants using foliage dust of tree species along an urbanization gradient. International Conference on Atmospheric Dust, June 1-6. 2014., Bari, Italy (L)

20. Edina Baranyai, Edina Simon, Mihály Braun, Béla Tóthmérész: The effect of firework on the elemental concentration of dust deposited on tree leaves. *X. Carpathian Basin Conference on Environmental Science*, March 27-29. 2014., Cluj-Napoca, Romania (L)

21. József Posta, Imre Tóth, Edina Baranyai, Dávid Nagy: Environmental and morphologycal analysis of urban dust. *XIV Hungarian-Italian Symposium on Spectrochemistry*, 5-7. Oct. 2011, Sümeg, Hungary (P)

22. József Posta, Imre Tóth, Edina Baranyai, Dávid Nagy: Chemical and morphologycal analysis of urban dust. *Colloquium Spectroscopicum Internationale XXXVII,* 28. Aug. – 2. Sept 2011., Rio de Janeiro (Búzios), Brasil (L)

23. József Posta, Imre Tóth, Edina Baranyai, Dávid Nagy: The environmental and morphologycal analysis of urban dust. *International Conference in Arad: Natural and Artifical Ecosystems in the Somes-Cris-Mures-Tisa River Basin,* May 7-8. 2010., Arad, Romania (L)

National conferences

24. Baranyai Edina, Simon Edina, Braun Mihály, Tóthmérész Béla: Urbanizáció hatása falevelek és falevélen kiülepedett por elemösszetételére. *VII. Magyar Természetvédelmi Biológiai Konferencia,* 2011. november 3-5., Debrecen (L)
25. Baranyai Edina, Tóth Imre, Nagy Dávid, Posta József: A városi porminták környezetanalitikai és morfológiai vizsgálata. *53. Magyar Spektrokémiai Vándorgyűlés és Vegyészkonferencia*, 2010. június 30. – július 2., Hajdúszoboszló (L)

Impact factor of published/accepted articles: 16,594
Impact factor of published/accepted articles connected to the thesis: 5,903

DEBRECENI EGYETEM
EGYETEMI ÉS NEMZETI KÖNYVTÁR

Nyilvántartási szám: DEENK/136/2015.PL
Tárgy: PhD Publikációs Lista

Jelölt: Baranyai Edina
Neptun kód: SCKQHK
Doktori Iskola: Kémiai Tudományok Doktori Iskola
MTMT azonosító: 10040303

A PhD értekezés alapjául szolgáló közlemények

Magyar nyelvű tudományos közlemény(ek) hazai folyóiratban (1)

1. **Baranyai E.**: Tölgyerdő, kertvárosi erdőterület és városi park fáinak levelén kiülepedestt por és a levelek elemtartalmának vizsgálata.
   Termvéd. Közl. 18, 45-57, 2012. ISSN: 1216-4585.

Idegen nyelvű tudományos közlemény(ek) külföldi folyóiratban (3)

2. **Baranyai, E.**, Simon, E., Braun, M., Tóthmérész, B., Posta, J., Fábián, I.: The effect of a fireworks event on the amount and elemental concentration of deposited dust collected in the city of Debrecen, Hungary.
   Air Qual Atmos Health. Epub, 2014. ISSN: 1873-9318.
   DOI: http://dx.doi.org/10.1007/s11869-014-0290-7
   IF: 1.804

3. Simon, E., **Baranyai, E.**, Braun, M., Cserháti, C., Fábián, I., Tóthmérész, B.: Elemental concentrations in deposited dust on leaves along an urbanization gradient.
   Sci. Total Environ. 490, 514-520, 2014. ISSN: 0048-9697.
   DOI: http://dx.doi.org/10.1016/j.scitotenv.2014.05.028
   IF:4.099

4. **Baranyai, E.**, Tóth, I., Nagy, D., Posta, J.: The chemical and morphological analysis of urban dust.
   Stud. Univ. "Vasile Goldis" Ser. Ştiinţ. vieţii. 21 (1), 71-75, 2011. ISSN: 1584-2363.

További Közlemények

Magyar nyelvű könyvrészlet(ek) (1)

5. Bodnár I., Boros N., **Baranyai E.**, Fórián S., Izbékiné Szabolcsik A., Jolánkai G., Üveges A., Kocsis D.: Épületek csapadékvizeinek és szürkevizeinek vizsgálata az Észak- Alföld régióban környezetbarát és energiahatékony hasznosítás céljából.
In: Fenntartható energetika megújuló energiaforrások optimalizált integrálásával. Szerk.: Kalmár Ferenc, Akadémiai Kiadó, Budapest, 167-201, 2014. ISBN: 9789630595407

Magyar nyelvű közlemény(ek) hazai folyóiratban (3)

6. Málnás K., Harangi S., Balogh Z., **Baranyai E.**, Braun M., Dévai G., Simon E.: Nehézfém analitikai vizsgálatok a Felső-Tisza és Szamos folyó hazai szakaszán.
Hidrol. Közlony. 94 (5-6), 62-65, 2014. ISSN: 0018-1323.

7. Fehér M., **Baranyai E.**, Bársony P., Simon E., Posta J., Stündl L.: A kobalt-klorid hatása a barramundi lárva (Lates calcarifer) termelési paramétereire és egyöntetűségére.
Agrártud. Közl. 51, 21-25, 2013. ISSN: 1587-1282.

8. Fehér M., Bársony P., **Baranyai E.**, Posta J., Stündl L.: Kedvező biológiai hatású mikroelemekkel dúsított Artemia alkalmazása a barramundi (Lates calcarifer) lárvanevelésében.
Agrártud. Közl. 48, 11-16, 2012. ISSN: 1587-1282.

Idegen nyelvű közlemény(ek) külföldi folyóiratban (4)

9. Bodnár, I., Szabolcsik, A., **Baranyai, E.**, Üveges, A., Boros, N.: Qualitative characterization of household greywater in the northern great plain region of Hungary.
Environ. Eng. Manag. J. 13 (11), 2717-2724, 2014. ISSN: 1582-9596.
IF: 1.065

10. Nagy, A., **Baranyai, E.**, Gáspár, A.: Interfacing microfluidic chip-based chromatography with flame atomic absorption spectrometry for the determination of chromium(VI).
Microchem J. 114, 216-222, 2014. ISSN: 0026-265X.
DOI: http://dx.doi.org/10.1016/j.microc.2014.01.008
IF: 2.746

11. Simon, E., **Baranyai, E.**, Braun, M., Fábián, I., Tóthmérész, B.: Elemental Concentration in Mealworm Beetle (Tenebrio molitor L.) During Metamorphosis.
Biol. Trace Elem. Res. 154 (1), 81-87, 2013. ISSN: 0163-4984.
DOI: http://dx.doi.org/10.1007/s12011-013-9700-1
IF:1.608

12. Fehér, M., **Baranyai, E.**, Simon, E., Bársony, P., Szűcs, I., Posta, J., Stündl, L.: The interactive effect of cobalt enrichment in Artemia on the survival and larval growth of barramundi, Lates calcarifer.
Aquaculture. 414-415, 92-99, 2013. ISSN: 0044-8486.
DOI: http://dx.doi.org/10.1016/j.aquaculture.2013.07.031
IF:1.828

Idegen nyelvű konferencia közlemény(ek) (2)

13. **Baranyai, E.**, Izbékiné Szabolcsik, A., Üveges, A.K., Bodnár, I.: Elemental analysis of grey water samples by microwave plasma atomic emission spectrometry.
In: International Congress on Water, Waste and Energy Management : Abstracts book. Ed.: Instituto Politécnico de Portalegre, [S.n.], Porto, 46, 2014. ISBN: 9789899508965

14. Szabolcsik, A., **Baranyai, E.**, Bodnár, I.: Utilization of modern analytical techniques for the analysis of household generated greywater samples.
In: Proceedings of Denzero International Conference: Sustainable energy by optmal integration of renewable energy sources. Ed.: Kalmár Ferenc, Debreceni Egyetem, Debrecen, 201-212, 2014. ISBN: 9789634737360

A közlő folyóiratok összesített impakt faktora: 13,15
A közlő folyóiratok összesített impakt faktora (az értekezés alapjául szolgáló közleményekre): 5,903

A DEENK a Jelölt által az iDEa Tudóstérbe feltöltött adatok bibliográfiai és tudománymetriai ellenőrzését a tudományos adatbázisok és a Journal Citation Reports Impact Factor lista alapján elvégezte.

Debrecen, 2015.06.30.