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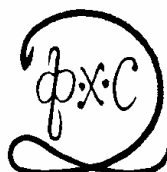
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## ANNUAL VARIATIONS OF FINE RESPIRABLE AEROSOL FRACTION IN URBAN RESIDENTIAL AREAS

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### ABSTRACT

Fine particulate matter fraction (PM 2.5) of urban aerosol collected daily for one year with 3/7 frequency at urban background locations in Banja Luka (BL) and Belgrade (BG) had been analyzed and discussed. Mass concentrations of aerosol deposit were determined by standard gravimetric procedure and concentrations of elements with antropogenic and crustal origin have been obtained by application of nuclear analytical techniques (PIXE, XRF). Resulted descriptive statistic parameters have shown that PM 2.5 annual limit value  $25 \mu\text{g m}^{-3}$  was exceeded during the heating period in both investigated regions but with significantly higher values in Banja Luka due to different heating type and structure and local traffic characteristics. Observed concentrations of S and K are high and based on other metals concentration some industrial influences have been indicated.

### INTRODUCTION

Numerous studies over the past decade have shown that a large proportion of diseases and deaths can be attributed to air pollution. Atmospheric particulate matter (PM) level turns as a key parameter in the cause/effect relationship between exposure to pollution and health impacts especially with high risk respirable fine particles, PM 2.5 [1]. The international and national legislative has stipulated annual mean limit value of  $25 \mu\text{g m}^{-3}$  for PM2.5 mass concentration. [2]. Apart the size, chemical composition of the particles and their capacity to carry potentially toxic substances such as organic substances or metallic compounds adsorbed on their surfaces have a crucial role to the effects. Trace elements may be released into the atmosphere by human activities, such as combustion of fossil fuels and wood, high temperature industrial activities and waste incinerations, gasoline exhaust emissions, etc. Urban antropogenic particles are mainly in the PM 2.5 range and its sampling diminishes the interference of natural sources. They could remain

in the air with relatively long residence time and could efficiently penetrate human lungs. Although PM 2.5 fraction of particulate matter is of a great concern for public health, no systematic studies have been performed in Balkans countries. The first measurements have been initiated in Belgrade, in 2002, Republic of Serbia, and in Banjaluka Bosnia and Herzegovina within this study. Here will be presented data on mass concentrations and chemical composition of PM 2.5 fraction of urban aerosol collected during 2014/15 as a starting point for the creation of short-term and long-term policy of air quality management

### EXPERIMENTAL

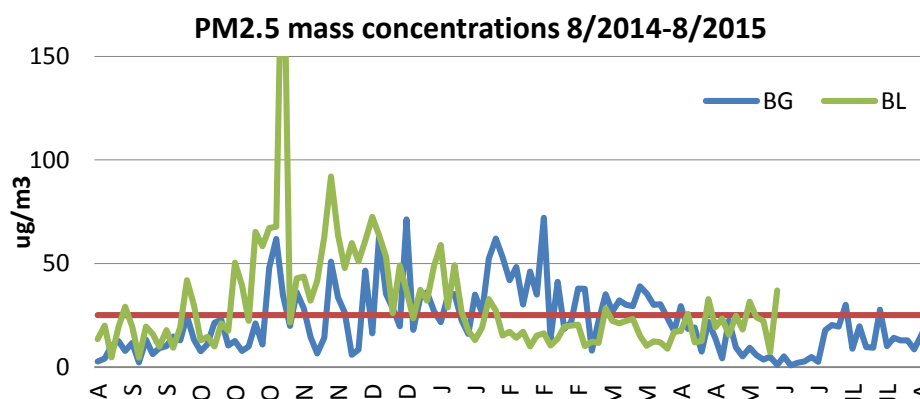
The air sampling of PM 2.5 aerosol fraction was performed from Aug 2014 till Aug 2015 at both locations using a MVS6 Sven Leckel reference samplers, with air flow rate 2.3m<sup>3</sup>/h. Suspended particles were collected on preconditioned (48 h at 20°C and constant relative humidity around 50%.) and pre-weighed PTFE filters exposed 24 hours with 3/7 frequency. Sampling locations were in Banja Luka (BL) urban background site (H<sub>s</sub>= 175m φ=44.75N, λ=17.24E) in residential area and in Belgrade (BG), sampling of PM 2.5 was performed at suburban site (H<sub>s</sub>= 243 m φ=44.78N, λ=20.52E) in residential area using the same standard procedures as in Banja Luka. The PM 2.5 mass concentration were determined by weighting of the unloaded and loaded preconditioned filters using semi-micro balance Mettler Toledo XS205DU (BL) and Sartorius, R 160P (BG) with a minimum resolution of 0.01 mg in accordance with EN12341 SOP.

Elemental analysis of PM 2.5 was done by nuclear analytical techniques XRF (BL) in Laboratory of Ion Beam Applications, NCSRE, Demokritos, Greece, and PIXE (BG) in Laboratory of Ion Beam Applications, institute of Nuclear Research, Hungarian Academy of Sciences. The elements observed within the study are: Al, Si, S, Cl, P, K, Ca, Na, Mg, Cr, Fe, Cu, Zn, Ni, Cd, As, Ti and V.

### RESULTS AND DISCUSSION

Gravimetric analysis of PTFE filters exposed in urban background areas of Belgrade and Banja Luka from Aug 2014 till Aug 2015 have shown daily mean values of PM 2.5 mass concentrations presented at Figure 1. Maximum concentrations may be noticed in heating period that was from 15 October to 15 April with the episode in Banja Luka in January 2015.

Statistical parameters of daily PM 2.5 mass concentrations (μg m<sup>-3</sup>) over the year have been determined for heating (H), non-heating (NH) and whole sampling time (All) as presented in Table 1.



**Figure 1.** Daily mean mass concentrations of PM 2.5 ( $\mu\text{g}/\text{m}^3$ ) in Belgrade (BG) and Banja Luka (BL) residential areas in 8/2014 -8/2015

The PM 2.5 mean 24-hours mass concentrations over the whole sampling time in Belgrade was  $20.63 \mu\text{g m}^{-3}$ , which is below annual limit given by national and European legislations ( $25 \mu\text{g m}^{-3}$ ) but it exceeded  $30.27 \mu\text{g m}^{-3}$  in Banja Luka.

**Table 1.** Statistical parameters of daily PM 2.5 mass concentrations ( $\mu\text{g m}^{-3}$ ) in Belgrade and Banja Luka in Aug 2014 to Aug 2015

Location	Time	N	Mean	SD	Max	Min	Median	98 <sup>th</sup>
Belgrade	NH	60	9.83	7.45	29.92	0.10	9.17	27.14
	H	71	29.76	15.63	72.10	5.84	29.40	67.81
	All	131	20.63	16.00	72.10	0.10	17.85	62.24
Banja Luka	NH	55	18.04	7.76	41.88	4.49	17.27	36.57
	H	45	45.22	34.73	233.61	9.84	41.54	108.97
	All	100	30.27	27.45	233.61	4.49	21.85	72.92

In general, seasonal variations are obvious with much higher concentrations in heating season, when maximum value  $29.76 \mu\text{g m}^{-3}$  was observed in Belgrade and  $45.22 \mu\text{g m}^{-3}$  in Banja Luka, both higher than prescribed annual limit value. Although Banja Luka have almost 10 times less inhabitants and vehicles than Belgrade the pollution by fine particulate matter is higher, probably due to different prevailing heating structure and type: combustion of fossil fuels or biomass burning, industry influences as well as

to the location characteristics and certain meteorological conditions e.g. inversed layers, low temperature and stagnation of air masses.

Besides the mass concentrations, elemental analysis of fine particulate matter aerosol fraction revealed seasonal variations of anthropogenic trace elements. The concentrations  $110.75 \text{ ng m}^{-3}$  Fe and  $9.40 \text{ ng m}^{-3}$  V are higher in Banja Luka than corresponding values in Belgrade:  $88.18 \text{ ng m}^{-3}$  and  $2.67 \text{ ng m}^{-3}$  respectively. Crustal elements Ca, Na, Mn, Al and Si have higher values in Banja Luka than in Belgrade that refer to soil dust as the main source. Concentration of Zn in Belgrade:  $22.50 \text{ ng m}^{-3}$  has higher value than in Banja Luka ( $6.68 \text{ ng m}^{-3}$ ) that is in accordance with earlier research [2]. Concentrations of Pb and Cu in Banja Luka has values  $5.56 \text{ ng m}^{-3}$  and  $3.96 \text{ ng m}^{-3}$  respectively, in compare with  $18.66 \text{ ng m}^{-3}$  and  $1.83 \text{ ng m}^{-3}$  in Belgrade. Concentration of K is significantly higher in Banja Luka ( $571.22 \text{ ng m}^{-3}$ ) than in Belgrade ( $319.53 \text{ ng m}^{-3}$ ) indicating biomass burning as a dominant heating fuel. Sulphure concentration is very high on both location with value  $1522.93 \text{ ng m}^{-3}$  in Banja Luka and  $1012.77 \text{ ng m}^{-3}$  in Belgrade indicated bad quality of coal and high contents of S in traffic emissions.

## CONCLUSION

Mean annual  $\text{PM}_{2.5}$  mass concentrations exceeded the EU air quality standard in Banja Luka in investigated time interval. Seasonal variations of elemental concentrations indicated a great influence of fuel combustion in the heating season. In general anthropogenic trace element are higher in Belgrade than in Banja Luka while the crustal elements have higher concentrations in Banja Luka.

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## REFERENCES

- [1] World Health Organization (WHO): 2003 *Health aspects of air pollution with particulate matter, ozone and nitrogen dioxide*. Report, RO Europe; Bonn, Germany 2003. EUR/03/5042688.
- [2] Tasić M, Rajšić S, Tomašević M, Mijić Z, Aničić M, Novaković V, Marković D. M, Marković D. A, Lazić L, Radenković M, Joksić J in: *Environmental Technologies, New Developments*, Ed.E. Burcu Ozkaraova Gungor, I-Tech Education and Publishing, Vienna, Austria, 2008:209-244



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