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AIR QUALITY INDICATION IN BLACE (SOUTHEASTERN SERBIA) USING LICHENS AS BIOINDICATORS

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Abstact - Air quality investigations have not been undertaken in Blace until now. Identifying the presence of different types of epiphytic lichens was performed in the summer 2012 in Blace (southeastern Serbia), and selected rural settlements around Blace, in order to establish the air quality of the area. The analysis of samples from described localities indicated the presence of 25 lichen taxa from 19 genera. Using the Index of Atmospheric Purity (IAP), it was found that there are 2 different air pollution zones in Blace: "lichen desert" and "transitional" or "struggle zone", which includes the periphery of the city. In these zones the air is moderately polluted. In the urban area of Blace there is no "normal" zone, but one was detected in the surrounding rural areas.

Key words: Air quality, bioindication, lichens, Blace, Serbia

INTRODUCTION

The quality of air is getting worse all over the world. The effect of air pollution on lichen distribution, diversity and abundance is the subject of numerous studies.

Lichens represent a symbiosis between a fungus (mycobiont) and alga or cyanobacterium (photobiont). Having a simple anatomy and a large surface area-to-volume ratio, lichens rely directly on atmospheric deposition for nourishment. They are highly valued ecological indicators, known for their sensitivity to air pollution. In recent times several papers have been published based on bioindication studies with lichens over the years (Savić, 1991; Stamenković, 1992; Milić and Blaženčić, 1993; Todorović, 1995; Stanković et al., 1999; Pejčinović, 2000). Bioindication of air quality, as well as the measuring of physical and chemical air pollution by using lichens has not been done in Blace until now.

The aim of this study was to assess air quality via examination of its bioindicator – lichen diversity and frequency.

MATERIALS AND METHODS

Sample location

The investigated points were located in the urban part of Blace, starting from the center of town towards outskirts, and included the surrounding rural areas. Blace is a relatively small city in southern Serbia, with a population of around 15000. The climate is moderate continental. The mean annual air temperature is

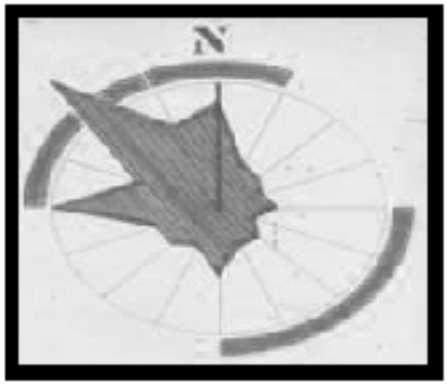

Fig. 1. Wind roses in Blace.

9.5°C (Table 1), and the mean annual rainfall is only 52.3 mm (Table 2). The prevailing winds blow from the north and north-westerly directions, bringing precipitation (Fig. 1).

Sample description

The analysis of samples from the described localities indicate the presence of 25 lichen taxa. Of these, *Xanthoria parietina* (L.) Th. Fr. was the most abundant. The substrate from the samples collected was the bark of the tree species *Acer pseudoplatanus* L., *Aesculus hippocastanum* L., *Malus domestica* Borkh., *Prunus domestica* L. and *Robinia pseudoacacia* L. Determination of the collected lichen species was done using identification books (Jahns and Masselink, 1982; Murati, 1992; Murati, 1993; Wirth, 1995; Dobson, 2005). We used the Index of Atmospheric Purity (IAP) according to Pirintsos (Loppi et al., 1997; Kricke and Loppi, 2002)

$$IAP = f$$

where f is the coefficient representing the frequency and cover of each species at a site.

RESULTS AND DISCUSSION

In 24 points in Blace and the surrounding rural area, 25 lichen taxa from 19 genera were found (Table 3). The most frequent species were *Xanthoria parietina* (95.8 %), *Phaeophyscia orbicularis* (83.3 %), *Physcia adscendens* (83.3 %), *Evernia prunastri* (75.0 %), *Parmelia sulcata* (70.8 %), *Melanelia subaurifera* (66.7 %) and *Candelariella xanthostigma* (66.7 %). Other taxa have significantly lower frequency.

Fig. 2. Investigated spots and zones of different air pollution levels in the city of Blace using lichens as bioindicators. Black dots indicate investigated spots,while the letters A and B indicate lichen desert and struggle zone, respectively.

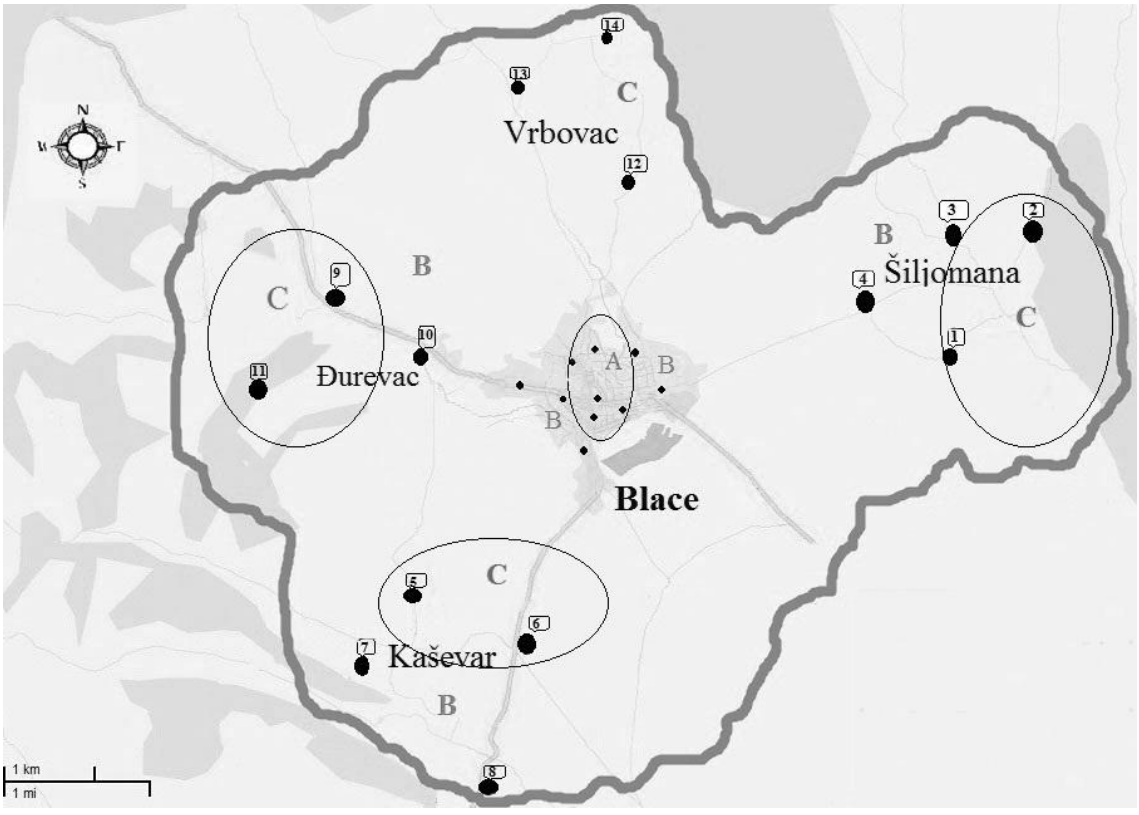

Fig. 3. Investigated spots and zones of different airpollution levels in the city of Blace and in the surrounding rural areas by using lichens as bioindicators. Black dots indicate investigated spots, letters A, B and C indicate lichen desert and struggle zone and normal zone, respectively. Finally, the gray line describes research area.

On the basis of calculated IAP values, we obtained a picture of the different air pollution levels in Blace (Fig. 2).

Zone A, or the "lichen desert" zone, with the highest air pollution level comprises almost the entire urban part of Blace. This zone encompasses five points (1, 2, 3, 4 and 10), which are characterized by low diversity and cover of lichens.

Zone B ("struggle zone") includes the periphery of the city and it had higher IAP values. In this zone the air is moderately polluted. In the urban area of Blace there is no a "normal" zone (zone C), but it was detected in the surrounding rural areas.

Zone C had a low level of air pollution and does not represent a continuous area. Based on the calculated values for IAP, we also got a picture of the different air pollution levels in the rural areas (Fig. 3).

This situation is not surprising given that metal, textile and rubber industries, which are now privatized and operate at reduced capacity, are present. Collecting, transporting, storing, and overall treatment of solid waste is insufficiently regulated and is one of the most important environmental problems on the territory of Blace.

Bearing in mind that there is no information about previous studies of this type in Blace, for comparison of results we used the data for lichen research in Knjaževac (Stamenković, 2010) and in Prokuplje (Stamenković, 1997). In these towns, air quality is identical according to the distribution of lichen air pollution indication zones.

Table 1. The average monthly air temperature (according to data of the Serbian Republic Hydro Meteorological Service)

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
T (°C)	0.6	0.5	4.4	9.2	13.3	16.8	20.8	19.7	14.2	9.8	4.0	1.6	9.5

Table 2. The averagemontly precipitation in Blace (according to data of the Serbian Republic Hydro Meteorological Service)

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
mm	44	40	40	55	74	72	55	42	31	64	60	51	52.3

Table 3. Values of coefficient f and frequency (%) for each lichen taxa and IAP for each investigated spot in the city of Blace and four surrounding villages (Šiljomana, Kaševar, Djurevac, Vrbovac).

Taxon/ Investigated spot/ Frequency	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	%
Amandinea punctata														3											4.17
Arthonia punctiformis																							2		4.17
Candelariella xanthostigma	1					1	1	1			1		2	1	1	1	1		1	1	2	1	1	2	66.67
Cladonia fimbriata											1			3											8.33
Evernia prunastri			1	1		1	4	2		1	1	4	2		1	4	3	2	1	1	1		2	3	75
Flavoparmelia caperata																					1				4.17
Hypogymnia physodes			1	1		1				1	1									1					25
Lecanora albella								2																	4.17
Lecanora caprinea																			1						4.17
Lecanora dispersa									1																4.17
Lecidella elaeochroma											1														4.17
Lepraria incana						1						1													8.33
Melanelia subaurifera				1	1	1	1		1		1	6	1	4		1	2		1	1	1		2	1	66.67
Parmelia glabratula								1																	4.17
Parmelia sulcata			1	1	2	1	1	1	1			2	2	2	1	1	1				1	2	1	1	70.83
Parmelia tiliacea			1																						4.17
Pertusaria albescens				1			4	2	1																16.67
Phaeophyscia orbicularis	3	2	2	2	5	2	3	1		1		1	2		2	3	3	1	1	2	2	2		1	83.33
Physcia adscendens	2	2	2		3	5		3	1		2	2	4	3	1	4	5		3	5	3	2	2	2	83.33
Physconia grisea												1	1	1		1			1	1	1		1	2	37.5
Physcia stellaris.																								1	4.17
Ramalina fastigiata								1																	4.17
Rinodina roboris						1																			4.17
Usnea hirta					1																				4.17
Xanthoria parietina	3	2	1	2	8	3	2	3	3	1	5	1	2	5	3	2	3		3	3	4	4	2	1	95.83
I A P	**8**	**5**	**7**	**6**	**19**	**14**	**16**	**13**	**7**	**3**	**13**	**18**	**14**	**22**	**8**	**16**	**15**	**3**	**12**	**14**	**16**	**10**	**13**	**14**	/

CONCLUSION

Epiphytic lichens are valuable bioindicators/biomonitors of air quality. A bioindication and physical-chemical investigation of air pollution in Blace has not been carried out to date. Blace is a small town in southern Serbia. In the present study, 25 lichen taxa from 19 genera were found in 24 investigated localities.. Lichens were collected from the barks of the tree species *Acer pseudoplatanus* L., *Aesculus hippocastanum* L., *Malus domestica* Borkh., *Prunus domestica* L. and *Robinia pseudoacacia* L. at a height of 1.5-2 m, exclusively from trunks angled up to 5^0. According to the calculated IAP values, we created pictures of the zones of different air pollution levels spreading over Blace and the surrounding rural areas. Zone A, with the highest air pollution level, comprises almost the entire urban area of Blace. Zone B includes the periphery of the city and had higher IAP values, and finally, Zone C, which was detected in the surrounding rural areas. It is desirable to repeat this study, given that the best results are achieved by continuity of successive detection.

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