

UDC 582.29:504.3.054(497.11)
Original scientific paper

MIRKO CVIJAN, BRANKA TODOROVIĆ, VESNA JOKSIMOVIĆ

THE LICHENS AS BIOINDICATORS OF AIR POLLUTION IN THE TOWNS OF MALI ZVORNIK AND ARANĐELOVAC (YUGOSLAVIA)

Institute of Botany and Botanical Garden „Jevremovac”, Faculty of Biology,
University of Belgrade

Cvijan, M., Todorović, B., Joksimović, V. (1995): *The lichens as bioindicators of air pollution in the towns of Mali Zvornik and Aranđelovac (Yugoslavia)*. – Glasnik Instituta za botaniku i botaničke bašte Univerziteta u Beogradu, Tom XXIX, 175 - 186.

The results of the study of lignicolous flora of lichens found in Mali Zvornik and Aranđelovac town are presented here.

By examining the collected samples, the presence of 15 genera with 33 species and 12 genera with 29 species were established in Mali Zvornik and Aranđelovac, respectively.

On the basis of the distribution of determined taxa and by using qualitative scale for air pollution, three zones (with two subzones) in terms of air pollution were established in Mali Zvornik, and only two zones in Aranđelovac.

Key words: air, pollution, lichens, bioindication, Mali Zvornik, Aranđelovac

Ključne reči: vazduh, zagađenje, lišajevi, bioindikacija, Mali Zvornik, Aranđelovac.

INTRODUCTION

The papers concerned with the study of lichens and the correlation of their development with air pollution, are numerous (see Savić *et al.*, 1996). Unfortunately, papers dealing with lichens occurring in Serbia are scarce. However, in the past few years, there has been a surge of interest for the investigation of urban lichens as bioindicators of air pollution (Cvijan *et al.*, 1992; Stamenković, 1992; Milić, Blaženčić, 1993; Cvijan, Stamenković, 1996).

The results of the study of lignicolous flora of lichens found in two small Serbian towns, in contrast to previously investigated big ones with very high air pollution, are presented here. By using bioindication values of numerous species, adequate zones in terms of air pollution (especially with sulphurdioxide) have been established.

MATERIAL AND METHODS

Samples of lichens were collected from wooden surfaces of various type, mainly bark, from the urban territory of Mali Zvornik (May-August 1992) and Arandelovac (spring 1992).

The analysed samples were gathered from 59 and 91 points in Mali Zvornik and Arandelovac, respectively. The points were precisely marked on the maps of Mali Zvornik and Arandelovac along with the data on the type of surface the lichens were collected from.

The collected material was examined in the Institute of Botany and Botanical Garden „Jevremovac” in Belgrade by using the available literature (see Savić *et al.*, 1996).

RESULTS AND DISCUSSION

MALI ZVORNIK (Little Zvornik) is a small town in Podrinjska area, with small number of inhabitants. It lies on the right bank of the Drina river (Fig. 1). The town area has very heterogeneous relief, the average altitude of which is 160 m. The climate is moderately continental with average annual temperature of 10°C (apsol. max. 34, apsol. min. -16°C) and average annual precipitation of 1025 mm. The west and north-west winds prevail and also south-west in the spring. However, the influence of the Drina river and great differences in the altitude between various points within the town area, are very important.

Although Mali Zvornik has prerequisites for good quality of air, still it is polluted. Namely, there are many boiler plants for heating of individual houses and big buildings. Some factories, especially lime-kiln, also use oil and coal for heating and for normal working process round the year. There is also mechanical pollution brought about by small parts of dust particles from the quarry „Bučevski potok” and from the stone cube production plant at the locality Radalj. The main communication routs passing through the greatest part of the urban area of Mali Zvornik, and heavy transit traffic have also harmful impact on the air quality.

By examining the collected samples, the presence of 15 genera with 33 species was established (Tab. 1).

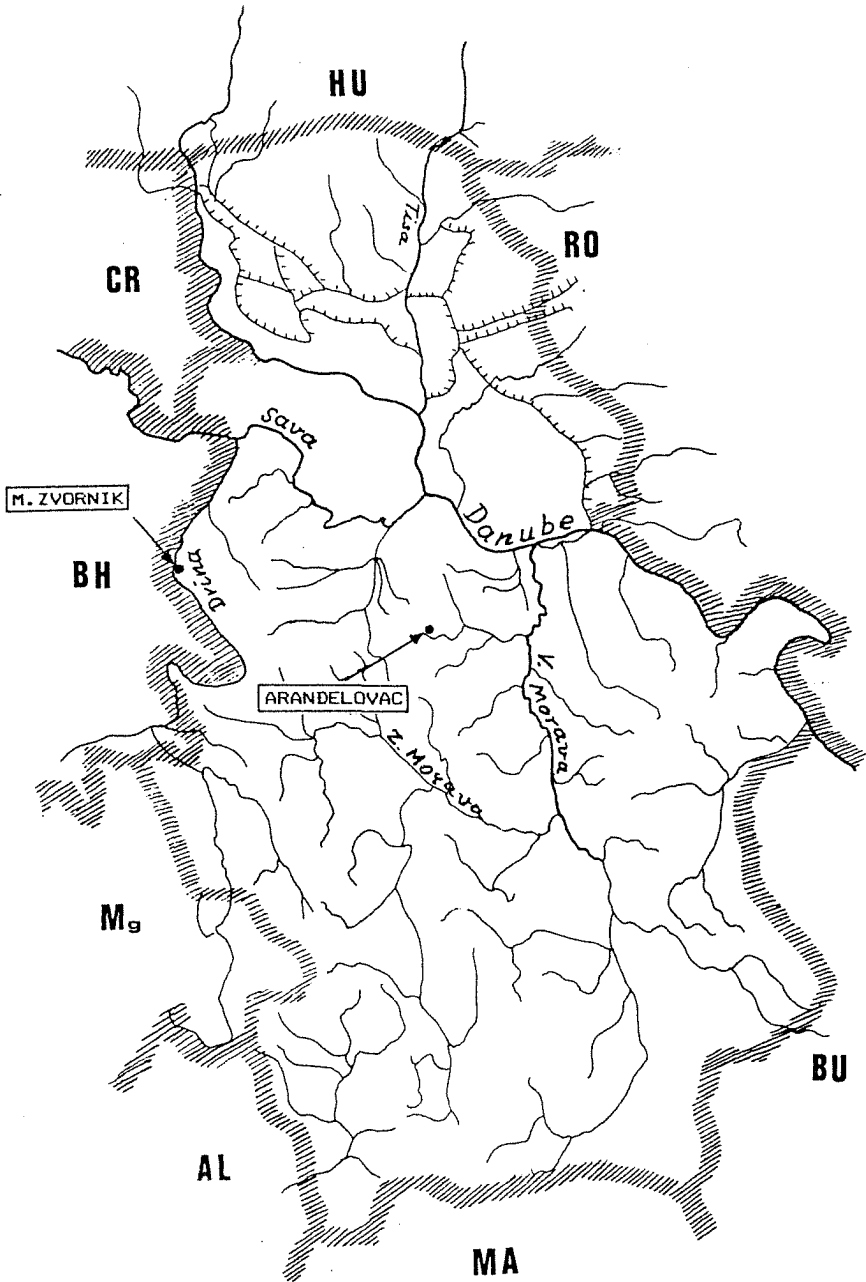


Fig. 1. – The investigated towns in Serbia
Istraženi gradovi u Srbiji

Tab. 1. – The determined lichen taxa from urban territory of investigated towns
 Određeni taksoni lišajeva sa urbanog područja istraženih gradova

Nos.	Taxa	presence	
		M. Zvornik	Arandelovac
1.	<i>Arthonia dispersa</i> (Schrad.) Nyl.	+	
2.	<i>Arthonia radiata</i> (Pers.) Ach.	+	
3.	<i>Arthothelium sardoum</i> Bagl.		+
4.	<i>Buellia punctata</i> (Hoffm.) Massal.	+	+
5.	<i>Caloplaca aurantiaca</i> (Lightf.) Th. Fr.	+	+
6.	<i>Caloplaca luteoalba</i> (Turn.) Th. Fr.	+	
7.	<i>Candelariella xanthostigma</i> (Pers.) Lett.	+	+
8.	<i>Cladonia fimbriata</i> (L.) Fr.	+	
9.	<i>Evernia prunastri</i> (L.) Ach.	+	+
10.	<i>Graphis elegans</i> (Sm.) Ach.	+	
11.	<i>Graphis scripta</i> (L.) Ach.	+	+
12.	<i>Hypogymnia physodes</i> (L.) Ach.	+	+
13.	<i>Lecanora campestris</i> (Schaer.) Hue	+	
14.	<i>Lecanora carpinea</i> (L.) Vain.	+	+
15.	<i>Lecanora chlarona</i> (Ach.) Nyl.		+
16.	<i>Lecanora chlarotera</i> Nyl.	+	
17.	<i>Lecanora intumescens</i> (Rebent.) Rabenh.	+	+
18.	<i>Lecanora subfusca</i> (L.) Ach. em. Hue	+	+
19.	<i>Lecanora</i> sp.		+
20.	<i>Lepraria aeruginosa</i> (Wigg.) Sm.	+	+
21.	<i>Lepraria</i> sp. Ach.	+	
22.	<i>Opegrapha atra</i> Pers.	+	
23.	<i>Parmelia caperata</i> (L.) Ach.	+	+
24.	<i>Parmelia dubia</i> (Wulf.) Schaer.	+	
25.	<i>Parmelia fuliginosa</i> (Fr.) Nyl.	+	+
26.	<i>Parmelia perlata</i> (Huds.) Ach.		+
27.	<i>Parmelia quercina</i> (Willd.) Vain.		+
28.	<i>Parmelia saxatilis</i> (L.) Ach.	+	+
29.	<i>Parmelia scortea</i> Ach.		+
30.	<i>Parmelia sulcata</i> Tayl.	+	+
31.	<i>Pertusaria albescens</i> (Huds.) Chosisy et Wern.	+	
32.	<i>Pertusaria isidioides</i> (Schaer.) Arn.	+	
33.	<i>Physcia aipolia</i> (Ehrht.) Hampe	+	+
34.	<i>Physcia ascendens</i> Bitter	+	+
35.	<i>Physcia caesia</i> (Hoffm.) Hampe	+	
36.	<i>Physcia grisea</i> (Lamk.) Lett.		+
37.	<i>Physcia leptalea</i> (Ach.) DC.		+
38.	<i>Physcia orbicularis</i> (Neck.) Poetch. em DR.	+	+
39.	<i>Physcia pulverulenta</i> (Schreb.) Hampe.	+	+
40.	<i>Physcia stellaris</i> (L.) Nyl. em Harm.		+
41.	<i>Physcia tenella</i> (Scop.) DC.	+	+
42.	<i>Xanthoria fallax</i> (Hepp) Arn.		+
43.	<i>Xanthoria parietina</i> (L.) Beltr.	+	+
Total:		34	30

The individuals of determined lichens were gathered from the bark of various trees (Tab. 2).

Tab. 2. – *The investigated points in Mali Zvornik with determined lichen taxa*
Istražene tačke u Malom Zvorniku sa taksonima lišajeva koji su određeni

Nos. of sampl.	Points of sampling	Types of surface	Nos. of taxa from Tab. 1.
1.	Radnička street	<i>Aesculus hippocastanum</i> L.	1, 4, 13, 20, 30, 28, 33, 34, 36, 38, 41, 43
2.	”	<i>Juglans regia</i> L.	4, 13, 17, 34, 43
3.	”	<i>Acer pseudoplatanus</i> L.	33, 34
4.	”	<i>Prunus domestica</i> L.	4, 34
5.	”	<i>Prunus avium</i> L.	30, 34
6.	”	<i>Thuja orientalis</i> L.	34
7.	settlement Vile	<i>Juglans regia</i> L.	2, 4, 5, 6, 14, 16, 22, 30, 34, 38, 43
8.	”	<i>Populus nigra</i> L.	1
9.	”	<i>Quercus robur</i> L.	34
10.	”	<i>Malus sylvestris</i> Miller	8, 9, 23, 33, 34, 38, 43
11.	”	<i>Betula pendula</i> Roth.	34, 43
12.	”	<i>Tilia argentea</i> Desf.	1, 11
13.	”	<i>Prunus domestica</i> L.	12, 13, 24, 34, 38, 43
14.	”	<i>Morus nigra</i> L.	34, 38, 41, 43
15.	”	<i>Acer campestre</i> L.	4
16.	”	<i>Fraxinus excelsior</i> L.	22
18.	”	<i>Prunus avium</i> L.	23, 30
19.	Bučevački brook	<i>Robinia pseudoacacia</i> L.	38, 43
20.	”	<i>Juglans regia</i> L.	11, 22, 43
21.	”	<i>Cornus mas</i> L.	32,
22.	distribution plants	<i>Juglans regia</i> L.	38, 43
23.	Miloša Gajića street	<i>Prunus avium</i> L.	11
24.	”	<i>Morus nigra</i> L.	38, 43
25.	”	<i>Prunus domestica</i> L.	7, 34, 43
26.	Zvezdara	<i>Tilia argentea</i> Desf.	2
27.	”	wooden enclosure	1
28.	”	<i>Prunus avium</i> L.	38, 43, 28, 7
29.	”	<i>Fraxinus excelsior</i> L.	1
30.	”	<i>Quercus</i> L.	7, 24, 28, 31, 34
31.	”	<i>Robinia pseudoacacia</i> L.	1
32.	” (margin of forest)	<i>Robinia pseudoacacia</i> L.	38
33.	Maršal Tito street	<i>Populus nigra</i> L.	4, 34, 43
34.	”	<i>Juglans regia</i> L.	34, 43
35.	”	<i>Prunus avium</i> L.	7, 30, 34, 38
36.	”	<i>Tilia argentea</i> Desf.	7, 24, 34, 38, 43

37.	"	<i>Sambucus nigra</i> L.	38, 43
38.	"	<i>Taxus bacata</i> L.	7, 34, 38, 43
39.	"	<i>Robinia pseudoacacia</i> L.	4, 35
40.	"	<i>Fraxinus ornus</i> L.	39, 43
41.	"	<i>Thuja orientalis</i> L.	34, 43
42.	"	<i>Aesculus hippocastanum</i> L.	33, 38, 43
43.	"	<i>Acer negundo</i> L.	34, 38, 43
44.	"	<i>Fraxinus excelsior</i> L.	34, 38, 43
45.	" park	<i>Salix alba</i> L.	6, 34, 38, 43
46.	Drinska street	<i>Prunus domestica</i> L.	34
47.	pontoon area	<i>Populus nigra</i> L.	34, 43
48.	"Progres" DMB area	<i>Populus nigra</i> L.	25, 30, 34, 43
49.	"	<i>Juglans regia</i> L.	4, 18, 38, 43
50.	"	<i>Fraxinus excelsior</i> L.	7, 25, 30, 34, 43
51.	"	<i>Prunus cerasus</i> L.	30, 34, 43
52.	"	<i>Prunus avium</i> L.	4, 34
53.	"	<i>Populus nigra</i> L.	41
54.	Medical station area	<i>Robinia pseudoacacia</i> L.	21, 38
55.	schoolyards	<i>Fraxinus ornus</i> L.	38, 43
56.	lime-kiln surrounding	<i>Corilus avelana</i> L.	10
57.	"	<i>Prunus domestica</i> L.	30, 34, 38
58.	"	<i>Alnus glutinosa</i> (L.) Gaet.	38, 43
59.	bank of the Drina river	<i>Salix alba</i> L.	38

On the basis of the distribution of determined taxa and by using qualitative scale for air pollution (H a w k s w a r t h , R o s e , 1970) three zones (with two subzones) in terms of air pollution, were established:

1. „lichen desert” zone (SO₂ concentration over 125 µg/m³ of air),
2. „Struggle” zone with:
 - a) inner part (SO₂ concentration about 100 µg/m³ of air),
 - b) outer part (SO₂ concentration about 60 µg/m³ of air), and
3. „Normal” zone (SO₂ concentration below 40 µg/m³ of air).

1. „Lichen desert” zone. It is situated in the small suburban part of the town (the river side and margins of the forest). High SO₂ level in the air is influenced by lime-kiln operation.

Potential „lichen desert” zone is the area which surrounds the quarry „Bučevski potok”, where only the rare individuals of no-bioindicator species of *Graphis scripta* and *Opegrapha atra* were found. In this case, qualitative and quantitative poisoning of lichens is influenced by the dust from the quarry (at the distribution plants, close to the quarry, dust concentration is 2.59 times over the maximal concentration allowed).

2. „Struggle” zone. This zone is divided into two parts.

The inner part of the „struggle” zone encircles a part of the settlement Vile. The high air pollution is influenced, in the first place by the transit traffic. The subzone has not quite clear boundaries because of the lack of adequate surface for the lichen development (mostly unhitewashed tress).

This subzone also encircles a part of the forest north of lime-kiln „Kamenita devojka”. Only the species *Parmelia sulcata*, *Physcia ascendens*, *Xanthoria parietina*, which tolerate average SO₂ concentration of about 70 µm/m³ of air, survive here.

Somewhat better quality of air in this subzone is influenced by the nearness of the River and forest (higher level of humidity, circulation of air along the river), and by north-west wind.

The outer part of the „struggle” zone encompasses the greatest part of the investigated area. The lichens, occurring close to distribution plant, are most poorly developed due to the dust from the quarry. On the contrary, the best qualitative and quantitative composition of lichen flora is in the urban part of the town, along the river.

3. „Normal” zone. It is situated, primarily, in the eastern part of the settlement Vile. Vile is near the forest and far from the central traffic communication routes. It is very rich in orchards. In addition to lichen species, which are susceptible to air pollution, there are some highly developed lichen species which are not bioindicators.

It should be noted that this zone is very close to the quarry. But, between Vile and the quarry there is the forest at the higher altitude than the quarry itself so that the winds and vertical circulations carry off the dust over the hill in the direction S-SE. In this way the air quality at Vile is protected.

ARANDELOVAC, including Bukovička Spa, is situated 75 km south of Belgrade (Fig. 1), at the altitude of 270 m but the difference between the highest and lowest points of the urban area is about 200 m.

The town is small with many prerequisites for good quality of air, especially great amount of green surfaces. Namely, in the territory of Arandelovac, the parks and the other green surfaces have about 60.22 ha (about 23 m³/inhabitant).

The climate is moderately continental with average annual temperature of 10.8°C (average temperature in January is -0.2°C, in July 20.6°C) and average annual precipitation of 753.5 mm. West and north-west winds prevail in spring and autumn, though south-east and north-east winds are not without influence.

The primary sources of air pollution are the boiler plants for heating of buildings and houses (52 are in the urban area, and 7 in the very center of the town), traffic (local and transit) and industry.

By examining the collected samples, the presence of 12 genera with 29 species was established (Tab. 1). Most of them were gathered from the bark of various trees (Tab. 3).

Tab. 3. – *The investigated points in Arandelovac with determined lichen taxa*
Istražene tačke u Arandelovcu sa tkasonima lišajeva koji su određeni

Nos. of sampl.	Points of sampling	Types of surface	Nos. of taxa from Tab. 1.
1.	Maršal Tito street	<i>Tilia argentea</i> Desf.	19, 34, 38, 43
2.	”	<i>Tilia platyphylla</i> Scop.	19, 38, 43
3.	”	<i>Populus nigra</i> v. <i>italica</i> (Much.) Duroi	19, 34
4.	Partizanska street	<i>Populus nigra</i> v. <i>italica</i>	19, 38
5.	”	<i>Juglans regia</i> L.	19, 34, 38, 43
6.	”	<i>Robinia pseudoacacia</i> L.	4, 34, 38, 43
7.	”	<i>Castanea sativa</i> Mill.	14, 38, 43
8.	”	<i>Pyrus domestica</i> Medic.	34, 38, 43
9.	M. Matijaševića street	<i>Juglans regia</i> L.	7, 38, 43
10.	Kosmajaska street	<i>Malus</i> sp.	38, 41, 43
11.	Vojina Gajića street	<i>Tilia platyphylla</i> Scop.	15
12.	”	<i>Populus nigra</i> v. <i>italica</i>	19, 38
13.	Prote Isakovića street	<i>Tilia platyphylla</i> Scop.	15, 19, 34, 38, 43
14.	”	<i>Robinia pseudoacacia</i> L.	4, 34, 38, 43
15.	”	<i>Fraxinus excelsior</i> L.	19, 34, 40, 41, 43
16.	cemetery ”Risovača”	<i>Tilia argentea</i> Desf.	11, 29, 38, 39, 43
17.	”	<i>Prunus avium</i> L.	4, 34, 41
18.	”	<i>Robinia pseudoacacia</i> L.	29, 40
19.	”	<i>Juglans regia</i> L.	11, 34, 40, 43
20.	Bregalnička street	<i>Pyrus domestica</i> Medic.	34, 39
21.	Narodnih heroja street	<i>Prunus armeniaca</i> L.	34, 38, 43
22.	”	<i>Pyrus domestica</i> Meced.	4, 7, 30, 34, 36, 43
23.	”	<i>Malus</i> sp.	34, 38
24.	Nenada Žakule street	<i>Prunus domestica</i> L.	4, 30
25.	Sl. Penezića street	<i>Robinia pseudoacacia</i> L.	34
26.	”	<i>Populus nigra</i> v. <i>italica</i>	4, 19, 34, 38, 43,
27.	”	<i>Juglans regia</i> L.	38, 41
28.	”	<i>Acer campestre</i> L.	34
29.	”	<i>Fraxinus excelsior</i> L.	34, 43
30.	Lomina street	<i>Tilia argentea</i> Desf.	4, 7, 19, 34, 38
31.	”	<i>Pyrus domestica</i> Medic.	4, 36
32.	”	<i>Fraxinus excelsior</i> L.	7, 36, 42
33.	I. Milutinovića street	<i>Fraxinus excelsior</i> L.	7, 34, 36, 38, 39, 42, 43
34.	”	<i>Tilia argentea</i> Desf.	36, 38, 42, 43
35.	”	<i>Prunus domestica</i> L.	34, 37, 40, 41
36.	”	<i>Populus nigra</i> v. <i>italica</i>	34, 38

37.	”	<i>Prunus avium</i> L.	30
38.	”	<i>Quercus</i> L.	34, 36, 40
39.	”	<i>Populus tremula</i> L.	4, 34
40.	Dušana Dugalića street	<i>Robinia pseudoacacia</i> L.	4, 7, 18, 30, 34, 37, 38
41.	”	<i>Juglans regia</i> L.	4, 38, 41, 43
42.	”	<i>Tilia argentea</i> Desf.	5, 12, 26, 30
43.	”	<i>Prunus domestica</i> L.	12, 30
44.	”	<i>Morus alba</i> L.	41
45.	Vojvode Stepe street	<i>Pyrus domestica</i> Medic.	34, 38, 41, 43
46.	”	<i>Prunus domestica</i> L.	30, 37, 42
47.	”	<i>Robinia pseudoacacia</i> L.	4, 34, 38
48.	”	<i>Quercus</i> L.	3, 7, 34, 36, 38,
49.	”	<i>Juglans regia</i> L.	34, 38, 43
50.	Ivo Lola Ribar street	<i>Acer campestre</i> L.	34, 37, 38
51.	”	<i>Fraxinus excelsior</i> L.	34, 43
52.	”	<i>Tilia platyphylla</i> Scop.	34, 38
53.	”	<i>Robinia pseudoacacia</i> L.	4, 12, 29
54.	”	<i>Quercus</i> L.	25, 29, 38, 41
55.	”	<i>Populus nigra</i> v. <i>italica</i>	34, 38
56.	Tanjugova street	<i>Tilia platyphylla</i> Scop.	29, 38, 39
57.	”	<i>Juglans regia</i> L.	4, 5, 7, 19, 38, 43
58.	”	<i>Populus nigra</i> v. <i>italica</i>	29, 38, 43
59.	Moše Pijade street	<i>Tilia argentea</i> Desf.	38, 40
60.	”	<i>Juglans regia</i> L.	38, 43
61.	”	<i>Salix</i> L.	30, 38
62.	”	<i>Prunus domestica</i> L.	19, 30, 38, 41
63.	”	<i>Malus</i> Mill.	38, 43
64.	”	<i>Acer platanoides</i> L.	34, 38
65.	”	<i>Populus nigra</i> L.	17, 19, 38, 43
66.	”	<i>Pyrus domestica</i> Medic.	34, 37, 38
67.	Milana Ilića street	<i>Populus nigra</i> v. <i>italica</i>	34, 38
68.	”	<i>Fraxinus excelsior</i> L.	4, 19, 28, 34, 38, 40, 43
69.	”	<i>Populus tremula</i> L.	4, 7, 19, 30, 34, 38, 43
70.	Milana Savkovića street	<i>Populus nigra</i> v. <i>italica</i>	4, 7, 19, 34, 38, 43
71.	29. Novembra street	<i>Populus nigra</i> v. <i>italica</i>	19, 34, 38
72.	”	<i>Pyrus domestica</i> Medic.	34, 36, 38
73.	M. Blagojevića street	<i>Pyrus domestica</i> Medic.	28, 34, 37, 38, 41
74.	”	<i>Juglans regia</i> L.	19, 34, 37, 38
75.	I Šumad. odreda street	<i>Salix</i> L.	34, 38

76.	”	<i>Robinia pseudoacacia</i> L.	30, 34, 38
77.	JNA street	<i>Populus nigra</i> v. <i>italica</i>	7, 19, 34, 38, 41
78.	”	<i>Robinia pseudoacacia</i> L.	34, 38, 41
79.	”	<i>Acer campestre</i> L.	34, 36, 38, 41
80.	”	<i>Fraxinus excelsior</i> L.	4, 25, 38
81.	”	<i>Tilia platyphylla</i> Scop.	19, 38
82.	Vožda Karadžića street	<i>Pyrus domestica</i> Medic.	17, 19, 34, 38
83.	”	<i>Populus nigra</i> v. <i>italica</i>	34, 38, 41
84.	”	<i>Tilia argentea</i> Desf.	34, 38, 40, 43
85.	”	<i>Robinia pseudoacacia</i> L.	19, 34, 43
86.	Lenjinova street	<i>Malus</i> Mill.	34, 38
87.	”	<i>Tilia platyphylla</i> Scop.	34, 40
88.	”	<i>Fraxinus excelsior</i> L.	34, 38, 40
89.	”	<i>Morus alba</i> L.	33, 34
90.	”	<i>Juglans regia</i> L.	33, 34, 37, 38
91.	The slopes of mt Bukulja	<i>Quercus</i> L.	4, 9, 12, 20, 23, 27, 29, 30, 33, 36, 37, 41, 43

On the basis of the distribution of the determined taxa, two zones, in terms of air pollution, were established:

1. „Struggle” zone and
2. „Normal” zone.

1. „**Struggle**” zone. This zone encircles the central part of the town where the most abundant are *Buellia punctata* and *Lecanora* sp. mixed with *Physcia tenella*, *Ph. ascendens*, *Ph. orbicularis* and *Xanthoria parietina*. The thalli of the individuals of the two last mentioned species were frequently more or less damaged.

On the basis of the distribution of lichen taxa and quality of their thalli, it could be concluded that sulphurdioxide concentration in this zone never exceeds 100 µg/m³ of air and is usually significantly bellow this value.

2. „**Normal**” zone. This zone encompasses the „struggle” zone. The results of our study show that sulphurdioxide concentration in this zone is always bellow 70, and at the outskirts of the town always bellow 50 µg/m³ of air.

CONCLUSIONS

The results of the study of lignicolous flora of lichens found in two small Serbian towns are presented here.

The samples were collected from 59 and 91 poits in Mali Zvornik and Arandelovac, respectively.

MALI ZVORNIK (Little Zvornik) lies on the right bank of the Drina river. Although Mali Zvornik is a little town with small number of inhabitants, the air is polluted.

By examining the collected samples, the presence of 15 genera with 33 species was established.

On the basis of the investigations, three zones (with two subzones) in terms of air pollution were established.

Zone of „lichen desert” (SO_2 concentration over $125 \mu\text{g}/\text{m}^3$ of air) is situated in the small suburban part of the town (the river side and margins of the forest). High level of SO_2 is influenced by lime-kiln operation. Potential „lichen desert” zone is the area which surrounds the quarry „Bučevski potok”, where only the rare individuals of no-bioindicator species were found. The pooring of lichens is influenced by the dust from the quarry.

„Struggle” zone is divided into two parts.

The inner part (SO_2 concentration about $100 \mu\text{g}/\text{m}^3$ of air) encircles a part of the settlement Vile. The high level of air pollution is caused, in the first place by the transit traffic. The subzone has not quite clear boundaries because of the lack of adequate surface for the lichen development. This subzone also encircles a part of the forest north of lime-kiln „Kamenita devojka”.

The outer part (SO_2 concentration about $60 \mu\text{g}/\text{m}^3$ of air) encompasses the greatest part of the investigated area.

„Normal” zone (SO_2 concentration below $40 \mu\text{g}/\text{m}^3$ of air) is situated, primarily, in the eastern part of the settlement Vile.

ARANDELOVAC, including Bukovačka Spa, is situated 75 km south of Belgrade. The town is small with many prerequisites for good quality of air, especially great amount of green surfaces.

By examining the collected samples, the presence of 12 genera with 29 species was established.

On the basis of the investigations, two zones in terms of air pollution were established.

„Struggle” zone encircles the central part of the town. The results of the study show that SO_2 concentration in this zone never exceeds $100 \mu\text{g}/\text{m}^3$ of air and is usually significantly bellow this value.

„Normal” zone encompasses the „struggle” zone. The results of the study show that SO_2 concentration in this zone is always bellow 70, and at the outskirts of the town always bellow $50 \mu\text{g}/\text{m}^3$ of air.

REFERENCES

- Cvijan, M., Szabados, K. & Savić, S. (1992): Bioindikacija aerogazadenja na području grada Beograda pomoću lignikolnih lišajeva. – Elaborat, Institut za botaniku Biološkog fakulteta Univerziteta u Beogradu.
- Cvijan, M. & Stamenković, S. (1996): Bioindication of air pollution in Niš area by use of lichens. – *Ekologija* 31(1): 151-157.
- Hawksworth, O.L. & Rose, F. (1970): Qualitative scale for estimation of sulphur dioxide air pollution in England and Wels using epiphytic Lichens. – *Nature* 227: 145-148.
- Milić, M. & Blaženčić, J. (1993): Epifitski lišajevi grada Beograda. – *Glas. Inst. bot. i Bot. bašte Univ. u Beogradu* 24-25: 83-96.
- Savić, I., Popović, R., Kataranovski, D., Kataranovski, M. & Cvijan, M. (1996): Osnove metodologije u istraživanju uticaja faktora životne sredine na životinjski i biljni svet. – „Ekosistem i zdravlje”, Dani zavoda '95, XIV stručna konferencija, Odeljenje medicinskih nauka SANU, pp. 47-96, Beograd.
- Stamenković, S. (1992): Bioindikacija aerogazadenja lignikolnim lišajevima na području grada Niša. – Magistrski rad, Univerzitet u Beogradu.

Rezi me

MIRKO CVIJAN, BRANKA TODORVIĆ, VESNA JOKSIMOVIĆ

**LIŠAJEVI KAO BIOINDIKATORI ZAGAĐENJA VAZDUHA U MALOM
ZVORNIKU I ARANDELOVCU (JUGOSLAVIJA)**Institut za botaniku i botanička bašta „Jevremovac”, Biološki fakultet,
Univerzitet u Beogradu

U radu su prikazani rezultati istraživanja lignikolne flore lišajeva u mestima Mali Zvornik i Arandelovac.

Uzorci lišajeva sakupljeni su sa 59 tačaka u Malom Zvorniku, odnosno sa 91 tačke u Arandelovcu. Gotovo bez izuzetka podloga sa koje su skidani uzorci lišajeva bila je kora drveća.

Obradom sakupljenih uzoraka, u Malom Zvorniku je utvrđeno prisustvo 15 rodova lišajeva sa 33 vrste, a u Arandelovcu 12 rodova sa 29 vrsta.

Na osnovu distribucije lišajeva, te korišćenjem kvalitativne skale Hawksworth-Rous-a, utvrđeno je prisustvo i raspored odgovarajućih zona aerozagadenja, pre svega sumpordioksidom, u oba istražena mesta. U Malom Zvorniku je utvrđen niži kvalitet vazduha što se ogleda u postojanju zone „lišajske pustinje” koja nije nađena u Arandelovcu, dok su zona „borbe” i „normalna” zona, kao zone okarakterisane nižim koncentracijama sumpordioksida, nađene u oba mesta.