

LICHENS AS BIOINDICATORS OF AIR QUALITY IN DIMITROVGRAD (SOUTH-EASTERN SERBIA)

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Abstract - Air pollution detection in Dimitrovgrad has not been done yet. In this work different lichen have been used as a bioindication to establish different air pollution levels. At 18 investigated points 22 lichen taxa have been found. Using the Index of Atmospheric Purity (IAP) it has been found that there are 3 different air pollution zones in Dimitrovgrad: "lichen desert", "transitional" and "normal zone". The most sensitive lichen taxa in Dimitrovgrad are *Evernia prunastra*, *Ochrolechia pallescens*, *Parmelia sulcata*, and *Physcia tenella* and the most tolerant are *Phaeophyscia orbicularis*, *Physcia adscendens*, *Physconia distorta*, *Physconia grisea*, and *Xanthoria parietina*.

Keywords: Lichens, bioindicators, air quality, Dimitrovgrad, Serbia

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INTRODUCTION

The quality of air quality is getting worse all over the world. The presence and absence of lichens and different species around different pollution sources has been used for problems connected to air pollution. Many scientists have been dealing with this problem (Henderson, 1991, Henderson, 1993, Henderson, 1994, Nali et al., 2007, Jovan, 2008). Interest in this type of investigation started in Serbia in last decade of 20th century (Cvijan, Stamenkovic, 1996, Savić, 1998, Savić, Tibell, 2006, Stamenković, 1997). Bioindication of air pollution by using lichens has not been done in Dimitrovgrad until now. Dimitrovgrad is an urban settlement in south-eastern Serbia, near the border with the Republic of Bulgaria. It has a population of around 8 000. The climate of this city is moderate continental. The mean annual air temperature is 9.7°C, the mean annual air humidity is 72% and the mean annual rainfall is only 581.2 mm. (Fig. 1) The most frequent winds in Dimitrovgrad are southeasterly and easterly (Figure 2) Industry in Dimitrovgrad is not well developed and traffic has a relatively high intensity.

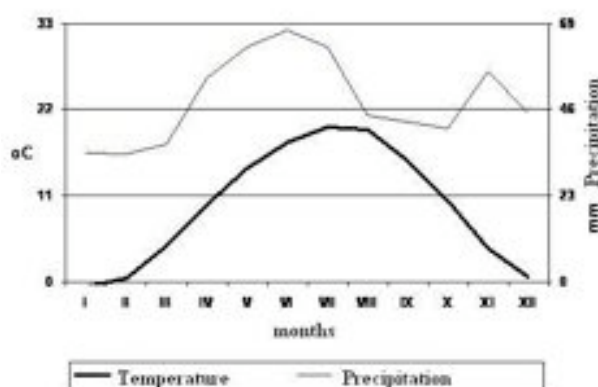


Fig. 1. Climate diagram for Dimitrovgrad (according to data of the Serbian Hydro Meteorological Service)

MATERIALS AND METHODS

Lichen samples in Dimitrovgrad were collected from 13 points. The investigated points are located in the urban part of Dimitrovgrad, starting from the center of town towards the last houses in the outskirts. Samples were collected from the bark of the tree species *Acer negundo* L., *Juglans regia* L.,

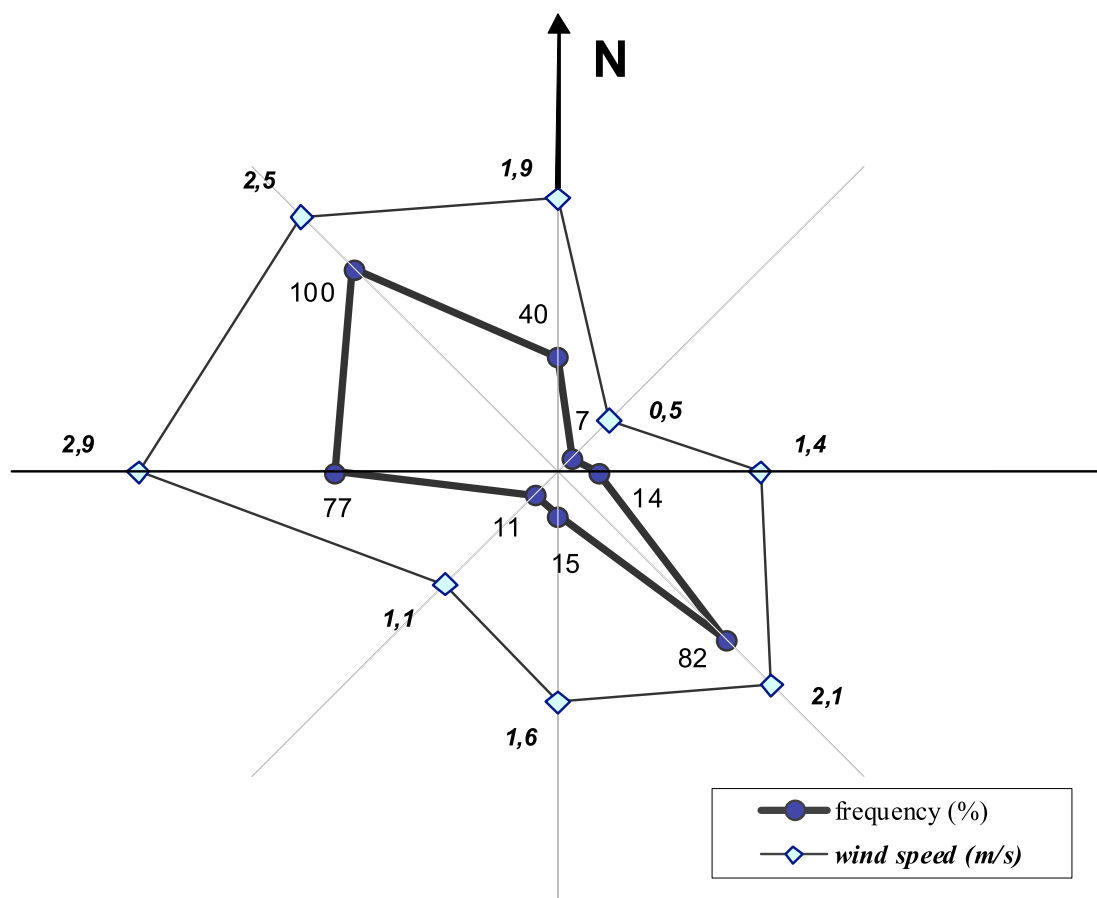


Fig. 2. Wind roses in Dimitrovgrad

Prunus domestica L., *Tilia platyphyllos* Scop. Determination of the collected lichen species was done using so-called identification books (Wirth, 1995, Dobson, 2005, Jahns and Masselink, 1982, Murati, 1992, Murati, 1993, Boqueras, 2000). In this research, we have used the numeric method of the Index of Atmospheric Purity (IAP) (Loppi et al., 1997, Kricke and Loppi, 2002).

$$IAP = \Sigma f$$

where: f is the coefficient representing the frequency and occupancy of each species at the site.

By marking the researched points on a city map and joining the points with the same or similar values of the IAP we obtained a picture of the zones

with different air pollution in Dimitrovgrad, using lichens as bioindicators (Figure 3).

RESULTS AND DISCUSSION

At 13 investigated points 19 lichen taxa from 11 genera (Table 1) were found. The most frequent species are: *Phaeophyscia orbicularis* and *Xanthoria parietina* (69.2 %), *Lecidella elaeochroma* (53.8 %), *Candelariella xanthostigma* (46.1%), *Buelia punctata*, *Physcia adscendens* and *Physcia stellaris* (38.4%).

According to the calculated IAP values, we obtained a picture of the zones of different air pollution levels throughout Dimitrovgrad (Figure 3).

Table 1. Values of *f* coefficient and frequency (%) for each lichen taxa and values of IAP for every investigated point in Dimitrovgrad

Taxa/inv. point	1	2	3	4	5	6	7	8	9	10	11	12	13	%
<i>Buelia punctata</i>	3			3		2	3			2				38.4
<i>Candelariella aurella</i>										1				7.69
<i>Candelariella xanthostigma</i>	3			3	2		3			3		2		46.1
<i>Evernia prunastri</i>								3						7.69
<i>Lecanora argentata</i>			3					2						15.38
<i>Lecanora intumescens</i>			4					3						15.38
<i>Lecanora sp.</i>			2	2				2		1				30.76
<i>Lecanora pulicaris</i>				1				2		2		2		30.76
<i>Lecidella elaeochroma</i>	2			3		2	3	3	2	3				53.83
<i>Ochrolechia pallescens</i>				3						2				15.38
<i>Parmelia sulcata</i>				3				2		3			1	30.76
<i>Phaeophyscia orbicularis</i>			3	4	4	3	5	3	3	4			3	69.2
<i>Physcia adscedens</i>	4					3	4	4			1			38.45
<i>Physcia stellaris</i>	3					1	2	2		3				38.45
<i>Physcia tenella</i>						3	3	3						23.0
<i>Physcia sp.</i>		1												7.69
<i>Physconia distorta</i>													2	7.69
<i>Physconia grisea</i>	1													7.69
<i>Xanthoria parietina</i>			3	4	4	2	3	2	3		1		3	69.2
IAP	16	1	15	26	10	16	26	31	8	24	2	4	8	/

A small area of the town, along the main city street, and forming a belt in a SW-NE direction, was characterized as a “lichen desert”. Around this area there is a zone that belongs to the “transitional zone”. This zone covers most of Dimitrovgrad (around 75-80%).

Points 6, 7, 8, and 10 have the highest IAP values. These points are located in the east part of the town and belong to a zone with lower air pollution level (“lichen normal zone”).

According to the IAP values a small area in Dimitrovgrad is located in a “lichen desert” (A). Further investigation of this zone could transform it into a “transitional zone” due to the presence of

some species (*Candelariella xanthostigma*, *Lecanora pulicaris* and *Lecidella elaeochroma*) which are moderately tolerant, and even sensitive, to air pollution. This fact suggests the possibility of an air improvement process with the consequence of lichen recolonization. Nonetheless, this presumption should be verified by further monitoring.

Such a picture of the different air pollution levels in Dimitrovgrad is a logical consequence of air pollution and the mixed influence of microclimate, substrate and geo-physical features, as well as the distribution of “green” areas and objects.

According to the qualitative lichen characteristics and calculated IAP values, a qualitative

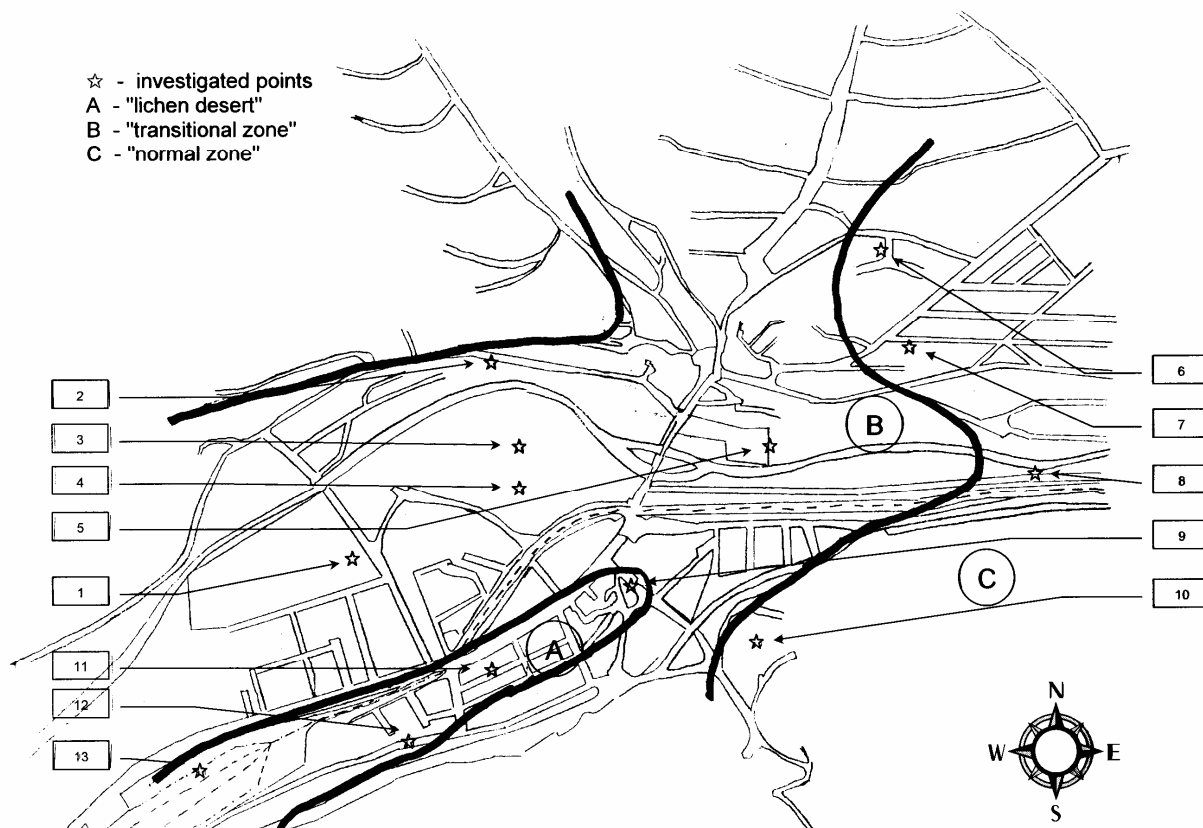


Fig. 3. Investigated points and different air pollution zones in Dimitrovgrad

assessment of lichen sensibility to air pollution has been made.

Very sensitive lichen taxa are: *Candelariella aurella*, *Evernia prunastri*, *Lecanora* sp., *Ochrolechia pallescens*, *Parmelia sulcata* and *Physcia tenella*.

Sensitive lichen taxa are: *Buelia punctata*, *Lecanora argentata*, *L. intumescens*, *L. pulicaris*, *Lecidella elaochroma* and *Physcia stellaris*.

Tolerant lichen taxa are: *Phaeophyscia orbicularis*, *Physcia adscendens*, *Candelaria xanthostigma*, *Physconia distorta*, *Physconia grisea* and *Xanthoria parietina*.

CONCLUSIONS

Dimitrovgrad is an urban settlement and without much large industry and traffic.

A bioindication and physical-chemical investigation of air pollution in Dimitrovgrad has not been carried out.

At 13 investigated points 19 lichen taxa from 11 genera have been found. The most frequent lichen taxa are: *Phaeophyscia orbicularis*, *Xanthoria parietina*, *Lecidella elaochroma* and *Candelariella xanthostigma*.

According to the calculated IAP (Index of Atmospheric Purity) values we created a picture of the zones of different air pollution levels spreading over Dimitrovgrad.

The zone with the highest air pollution level ("lichen desert") is located in the central and south-western part of Dimitrovgrad, in the form of thin and long belt. Almost all of the rest of the town is in a lichen "transitional zone". In this area, the air

is moderately polluted. A small part of Dimitrovgrad, on east side, belongs to the lichen "normal zone", with the lowest air pollution level.

By qualitative lichen sensitivity it was found that most sensitive lichen species are from the following genera: *Candelariella*, *Evernia*, *Ochrolechia*, *Parmelia*; less sensitive are species from the genera *Buelia*, *Lecanora*, *Lecidella* and *Physcia stellaris*. The most tolerant lichen taxa are *Phaeophyscia orbicularis*, *Candelariellaxanthostigma*, *Physcia adscendens*, *Phy. distorta*, *Phy. grisea* and *Xanthoria parietina*.

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REFERENCES

- Boqueras, M. (2000). Líquens epífits i fongs liquenícoles del sud de Catalunya: flora i comunitats, Institut d'Estudis Catalans.
- Cvijan, M. & S. Stamenković, (1996) Bioindication of air pollution in Nis area by use of Lichens. *Ekologija*, **31**, 151-157.
- Dobson, F. S. (2005) *Lichens*. Richmond, the Richmond Publishing Co. Ltd.
- Henderson, A. (1991) *Literature on Air Pollution and Lichens* XXXIV. *The Lichenologist*, **23**, 393-401.
- Henderson, A. (1993) *Literature on air pollution and lichens* XXXVIII. *The Lichenologist*, **24**, 435-441.
- Henderson, A. (1994) *Literature on air pollution and lichens* XL. *The Lichenologist*, **26**, 383-390.
- Jahns, H. & A. Masselink, (1982) *Farne, Moose, Flechten Mittel-, Nord-und Westeuropas*, München, BLV Verlagsgesellschaft.
- Jovan, S. (2008) *Lichen bioindication of biodiversity, air quality, and climate: baseline results from monitoring in Washington, Oregon, and California*, Portland, U.S. Dept. of Agriculture.
- Kricke, R. & S. Loppi, (2002) *Bioindication: the IAP approach*. IN NIMIS, P., SCHEIDEGGER, C. & WOLSELEY, P. (Eds.) *Monitoring with lichens-Monitoring lichens*. Dordrecht, Kluwer Academic.
- Loppi, S., Giovannelli, L., Pirintsos, S., Putorti, E. & A. Corsini, (1997) *Lichens as bioindicators of recent changes in air quality*(Montecatini Terme, Italy). *Ecologia mediterranea*, **23**, 53-56.
- Murati, M. (1992) *Flora lišajeva 1*, Priština, Univerzitet u Prištini, Viša pedagoška škola "Bajram Curri" Đakovica.
- Murati, M. (1993) *Flora na lišajte 2*, Skopje, Unijata na albanskata inteligencija vo Makedonija.
- Nali, C., Balducci, E., Frati, L., Paoli, L., Loppi, S. & G. Lorenzini, (2007) *Integrated biomonitoring of air quality with plants and lichens: A case study on ambient ozone from central Italy*. *Chemosphere*, **67**, 2169-2176.
- Savić, S. & L. Tibell, (2006) *Checklist of the lichens of Serbia*. *Mycologia Balcanica*, **3**, 187-215.
- Stamenković, S. (1997) *Biological indication of air pollution in Prokuplje by means of lignicolous lichens*. *Ekologija*, **32**, 107-110.
- Wirth, V. (1995) *Die Flechten Baden-Württembergs. Verbreitungsatlas*, **1&2**.

ЛИШАЈИ КАО БИОИНДИКАТОРИ КВАЛИТЕТА ВАЗДУХА У ДИМИТРОВГРАДУ (ЈУГОИСТОЧНА СРБИЈА)

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Димитровград је урбано насеље са око 8.000 становника и релативно слабо развијеном индустријом и интензитетом моторног саобраћаја.

Биоиндикаторска и физичко – хемијска истраживања аерозагађења у Димитровграду до сада нису спровођена.

На 13 истраживаних тачака пронађено је 19 таксона лишајева из 11 родова. Најучесталији таксони лишајева су: *Phaeophyscia orbicularis*, *Xanthoria parietina*, *Lecidella elaochroma* и *Candelariella xanthostigma*.

На основу израчунатих вредности ИАП (Индекс атмосферске чистоће) добијена је слика простирања зона различитог нивоа аерозагађења у Димитровграду.

Зона са највишим степеном аерозагађења ("лишајска пустиња") налази се у централном и југозападном делу Димитровграда у виду танког и дугачког каиша (појаса). Скоро сав остали део насеља налази се у лишајској "прелазној зони" и у том простору ваздух је умереног нивоа загађења. Мали део Димитровграда на источној страни припада лишајској зони ("нормална зона") са најнижим степеном загађења.

Квалитативном проценом осетљивости различитих таксона лишајева утврђено је да су најосетљивије врсте лишајева у Димитровграду из родова: *Candelariella*, *Evernia*, *Ochrolechia*, *Parmelia*, мање осетљиве врсте су из родова *Buelia*, *Lecanora*, *Lecidella* и *Physcia*. Најтолерантније врсте су *Phaeophyscia orbicularis*, *Candelariella xanthostigma*, *Physcia adscendens*, *Phy. grisea*, *Physconia distorta* и *Xanthoria parietina*.