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LICHENS AS INDICATORS OF AIR QUALITY IN BALNEOLOGICAL CENTER PROLOM BANJA (SOUTHERN SERBIA)

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Abstract: This paper deals with using lichens as a bioindicators of the air quality and it was conducted on the territory of balneological center Prolom Banja (Southern Serbia). The exploration was conducted in the year 2019. The analysis of the sample from 15 investigated points indicates the presence of 72 lichen taxa, which shows that this area is rich in lichen species. For each investigated point, the index values of atmospheric purity (*IAP*) and index of human impact (*IHI*) were calculated. The *IAP* values varied in range from 40 to 56, while *IHI* values ranged between 8 and 24. Therefore, the map showing the air quality of the investigated area was made. There is a presence of "normal lichen zone" on the map which indicates that the air quality in this area is quite good. There are no significant air pollution sources in this area, so the level of pollution is considered low or very low. In the investigated area there are not stations for the monitoring of physico-chemical parameters of air quality. The investigation of air quality on the territory of Prolom Banja has not been done until now.

Keywords: air quality; bioindication; lichens

Introduction

Air quality is a topic that attracts more and more attention and a problem that is gaining in importance. The negative effects of air pollution on human health are well known (Wu et al., 2016). On the basis of the available knowledge about the possible threats to air quality, there is a need to know the type and extent of the threat that has arisen (Hauck, de Bruyn, & Leuschner, 2013). The basis for improving air quality is detection and registration on time. This can be achieved by physico-chemical or biological monitoring.

Biological monitoring is based on the detection and monitoring of changes that occur on different levels of the biological organization for living beings under the influence of pollutants (Paoli et al., 2015). Lichens are indicator organisms that have significant use in the bioindication of

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air quality. Not all lichen species are equally likely to indicate different levels of air pollution. Previously conducted studies have shown that certain species of lichens are sensitive to air pollutants in the atmosphere while other ones are resistant to them (Gombert, Asta, & Seaward, 2004; Kricke & Loppi, 2002; Sujetovienė, 2015).

Many studies on air quality are based on testing of lichens, in which a large number of papers have described the air quality level in urban areas (Blasco, Domeño, & Nerín, 2008; Calvelo, Baccalá, & Liberatore, 2009; Gerdol, Marchesini, Lacumin, & Brancaleoni, 2014; Käffer et al., 2011; Kirschbaum, Cezanne, Eichler, Hanewald, & Windisch, 2012; Lisowska, 2011; Stamenković, Ristić, Đekić, Mitrović, & Baošić, 2013). Degtjarenko, Matos, Marmor, Branquinho, and Randlane (2018) suggested that lichen growth form, reproductive strategy, and tolerance to substrate pH could serve as potential tools for indicating the effects of dust pollution. The study conducted by Szwed, Kozłowski, and Żukowski (2020) showed a high level of lichen sensitivity to air quality changes created by anthropogenic impact. In different studies of biomonitoring of air quality, the degree of urbanization and traffic density are the basic causes of pollution in urban areas (Malaspina et al., 2014; Zhao et al., 2019).

This study used a method of lichen indication of air quality, which includes: the identification of lichens in the study area; spatial coverage analysis; calculation of the Index of Atmospheric Purity (*IAP*) and index of human impact (*IHI*); as well as mapping zones of different levels of air pollution within the investigated area. The research was conducted in 2019.

The aim of this investigation was to present the results of the indication of air quality in one of the most attractive spas in Serbia. The main objective of this study is to contribute to the knowledge in biogeography of lichens on the territory of balneological center Prolom Banja (in further Prolom Spa) and create the basis for the evaluation of lichens as air quality indicators of the investigated territory. There are no stations for physico-chemical measurements in Prolom Spa, so the air quality research was conducted in this area for the first time.

Materials and methods

Study area and sampling procedure

Prolom Spa is located 23 km southeast of Kuršumlija, on the southern slopes of Radan Mountain in southern Serbia (Figure 1). This spa center is located at an elevation of 598 m a.s.l. The settlement covers an area of 18.10 km^2, so this is one of the medium-sized settlements in the municipality of Kuršumlija (Perić, Stojiljković, Gašić, & Ivanović, 2017).

The climate of this area is moderately continental (Republic Hydrometeorological Service of Serbia, 2013). The average annual air temperature is 11.9 ºC (Republic Hydrometeorological Service of Serbia, 2019). The data were obtained from the nearest metrological station in the town of Kuršumlija. According to the last census, 131 inhabitants live in Prolom Spa (Statistical Office of the Republic of Serbia, 2011). It is the most developed and well-maintained spa in Serbia and it is also the largest tourist center of the municipality of Kuršumlija (Perić et al., 2017). The collection of materials was carried out across Prolom Spa (Figure 1). The research included the total of 15 investigated points in the investigated area.

Figure 1. Map of Serbia, Kuršumlija municipality (top); Investigated area of Prolom Spa (bottom). Adapted from Google Earth Pro, V 7.3.3.7721, "Prolom Spa", 43.024905°N, 21.235850°E (Image date: July 08, 2020) by Google, 2020 (https://www.google.com/earth/). Image copyright 2020 by CNES/Airbus.

Methodology

The investigated points have been chosen in accordance with the methodological criteria. Only such points which fulfilled the methodological criteria have been taken into account (five close trees of the same species). The coverage of the lichens was determined by a sampling ladder measuring 50 × 10 cm. When investigating epiphytic lichens, only trees at a height of 1 to 1.5 m from the ground, whose slope angle was less than 5°, were taken into consideration (Kricke & Loppi, 2002). The coverage of each lichen species is expressed in values from 0 to 10, on a scale characterizing the coverage: values 9–10 were assigned to species with a very high frequency of being found and a very high degree of coverage (80 to 100%); values 7–8 were assigned to species with high frequency or high coverage (60 to 80%); values 5–6 were assigned to species which are not often found or which have a small degree of coverage (40 to 60%); values 3–4 were assigned to species that are rare or have a low degree of coverage (20 to 40%); values 0–2 were assigned to species that are very rare and with a very low coverage (0 to 20%). The frequency of each species was calculated in relation to the percentage presence on the total number of the investigated points, after which the *IAP* was calculated and the air quality indication zones were mapped (Kricke & Loppi, 2002).

The numerical method for the calculation of the *IAP* was used in this study. *IAP* values were calculated by the following formula:

$$IAP = \sum f \quad (1)$$

where *f* stands for lichen coverage (Kricke & Loppi, 2002).

The *IAP* values were calculated for each investigated point within the investigated area. A scale was used to estimate the degree of air pollution and determine lichens indication zones (Conti & Cecchetti, 2001). Higher index values indicate better air quality, while lower values indicate that the air is of lower quality (Figure 2).

Level of air pollution	Very high	High	Moderately	Low	Very low
IAP values	0	12.5	25.0	37.5	50.0
Lichen indication zones	"Lichen desert"		"Struggle" zone		"Normal" zone

Figure 2. The assessment scale of air quality based on pollution levels and *IAP* values. Adapted from "Biological monitoring: lichens as bioindicators of air pollution assessment—a review" by M. Conti and G. Cecchetti, 2001, *Environmental Pollution, 114*, p. 474. Copyright 2001 by Springer Nature. Adapted with permission.

In order to the graph, the distribution of points with different *IAP* values, percentile maps were used where different colors represent different *IAP* values. Based on *IAP* values, three basic air quality zones are distinguished:

1. "Lichen normal zone" covers areas where the air is clean or free from significant air pollution (*IAP* > 37.5);
2. "Lichen struggle zone" includes a surface with a moderate level of pollution (12.5 < *IAP* ≤ 37.5);
3. "Lichen desert zone" covers the territory with the highest level of air pollution (0 < *IAP* ≤ 12.5).

The index of human impact (*IHI*) was calculated using the method of qualitative assessment (Conti & Cecchetti, 2001):

$$IHI = U\,(T + D + E) \qquad (2)$$

where *U* is urbanization (urban, suburban or rural areas), *T* is traffic (vicinity or distance from a road), *D* is local developments (crop fields, green areas, housing sites, car parks), and *E* exposure (trees isolated, in rows or grouped). Although these four parameters were estimated separately and independently, weak correlations were found between *U*, *T*, and *D*. Categories (from 1 and 4) were attributed to each parameter to express a gradient of alteration (Table 1).

Table 1
Assessment of quantitative variables basic environmental parameters

Parameters		
Urbanization (*U*)	Rural	Sub-urban and urban
	1	4
Traffic (*T*)	Weak road exposure	High road exposure
	1	4
Local developments (*D*)	Crop fields, Green areas	Housing sites, car parks and roads
	1	4
Exposure (*E*)	Trees isolated or in rows	Trees grouped
	1	4

Note. Adapted from "Assessment of lichen diversity by index of atmospheric purity (IAP), index of human impact (IHI) and other environmental factors in an urban area (Grenoble, Southeast France)" by S. Gombert, J. Asta, and M. R. D. Seaward, 2004, *Science of the Total Environment, 324*, p. 188. Copyright 2004 by Elsevier. Adapted with permission.

Results and discussion

The presence of 72 lichen species from 33 genera was noted in the area of Prolom Spa (Table A1). Fifty-seven species of epiphytic lichens were found—20 species with corticolous thalus, 31 species with a leaf type and six species with a bush type of thalus. The presence of 10 species of tericolous and five species of saxicol lichens was also observed. The most frequent species (100%) were: *Hypogymnia physodes*, *Lecidella elaeochroma*, *Parmelia sulcata*, *Phaeophyscia orbicularis*, *Physcia adscendens*, and *P. stellaris*, whose presence was observed at all survey points in Prolom Spa. In addition to this, the following species had extremely high frequency (93.33%): *Flavopermelia caperata*, *Hypogymnia tubulosa*, *Melanelixia subaurifera*, and *Xanthoria parietina*. Some species were presented with extremely low frequency (6.67%): *Lecanora confusa*, *L. glabrata*, *M. subargentifera*, *Parmelia consercers*, *Parmelina quercina*, *Physconia detersa*, *P. distorta*, *Rhizocarpon geographicum*, and *Rinodina colobina* (Table A1). The most common substrate on which the presence of lichens was observed and from which the samples of individual species were collected, was the bark of trees: *Quercus frainetto Ten*., *Q. cerris* L., *Prunus domestica* L., *Robinia pseudoacacia* L., and *Juglans regia* L.

At different investigated points, the presence of different numbers and composition of lichen taxa was observed, and consequently, the variation in *IAP* values was noted. The calculated IAP values ranged from 40 to 56. On the basis of the *IAP* values on the map of the studied area, a map of different degrees of air quality in the investigated area was obtained (Figure 3). The "normal zone" is shown on the *IAP* scale (Figure 3). It is characterized by low or very low pollution. This zone is characterized by *IAP* values > 37.5 (Figure 2), that is, most of the area includes points whose *IAP* values are from 40 to 50, while in the southeastern part of the investigated area, there are points whose values are *IAP* > 50. A "normal zone" is present throughout the investigated area. A closer look at the study area shows the division of the "normal zone" into three sub-zones A1, A2, and A3 (Figure 3). The first sub-zone (A1) is characterized by points 3, 7, 9, 10, 11, 13, 14, 15, which have the lowest IAP values (40 to 45) compared to the other investigated points of this area. The second sub-zone (A2) is characterized by points 1, 2, and 12, whose *IAP* values vary from 48 to 50. The third formed sub-zone (A3) is characterized by four study points—4, 5, 6 and 8. They cover mainly the southeastern part of the area and it has a discontinuous shape, so that its fragments are in the northwest (point 4). The *IAP* values found in this subzone vary from 52 to 55, while *IHI* values ranged between 8 and 24 (Figure 3).

According to the results, Prolom Spa is an area characterized by good air quality (Figure 3). The investigated area is characterized by high *IAP* values, and, according to the applied scale (Figure 2), the largest part of this investigated area is characterized by good air quality. A "lichen normal zone" (A) represents points with high *IAP* values, so subzones (A_1, A_2, and A_3) within the "normal zone" show a fine shading of parts of the area according to the *IAP* values. The first subzone comprises the socially active center of the investigated area, so as expected and consequently, the *IAP* values at the points in this subzone are the lowest, while the *IHI* values are the highest. The second subzone extends around the first and toward the periphery of the area. It covers parts of the investigated area that are less populated. The third subzone is not of a continuous shape. It comprises the southeastern part of the investigated area, and its fragments are in the northwest and are characterized by the investigated point 4. This point, although located in the populated part of the area, which was not the case with the location of the other points in this subzone, is characterized by relatively well-developed green areas, which, by definition, mitigate the negative effects of air pollution. It should be borne in mind that the stated zones of varying degrees of air quality are a reflection of their condition in a particular area over a long period of time (Gombert et al., 2004; Mayer et al., 2013).

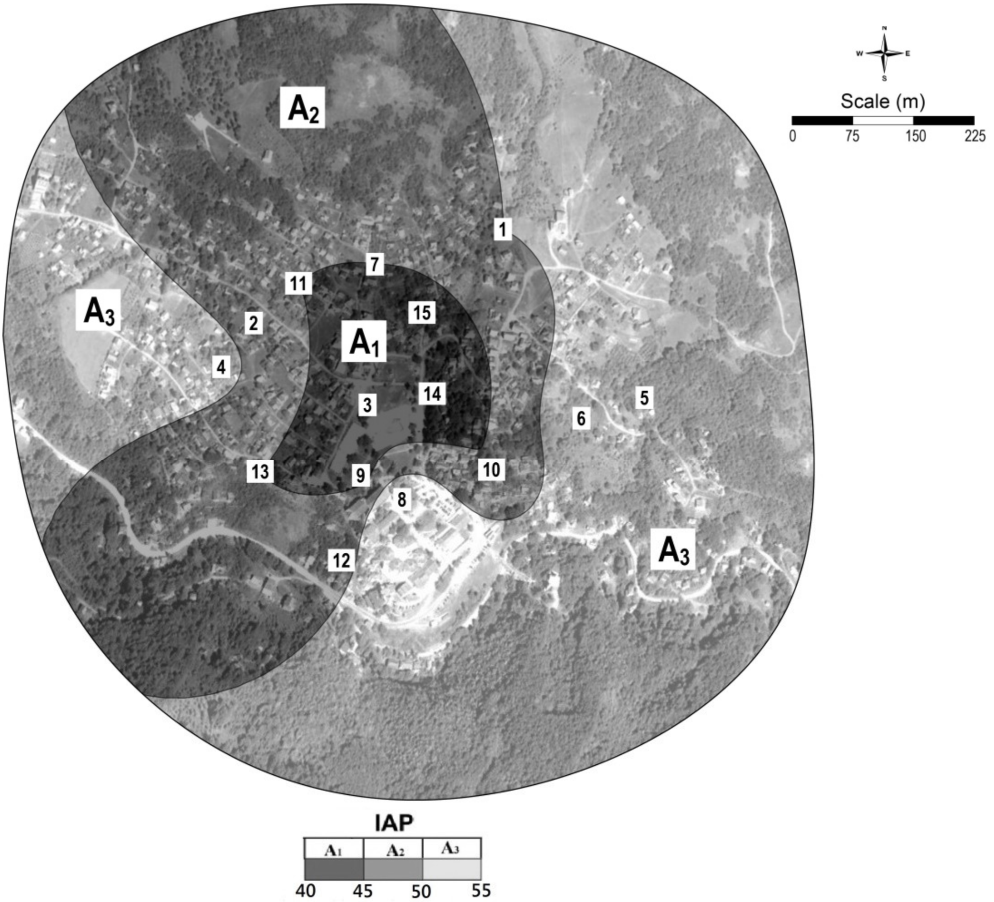

Figure 3. The spatial distribution of the "normal zone" indicaton of air quality in Prolom Spa (A1, A2, A3 subzones of the "normal zone"). The investigated points are marked with numbers from 1 to 15.

The variation of *IHI* values is dependent of the urbanization level and traffic intensity (Sujetovienė, 2015). The intensity of traffic, green area and individual heating units have a major impact on air quality (Stanojević et al., 2019). Similar results have been reported by previous studies conducted in various urban areas (Llop et al., 2012; Loppi, Ivanov, & Boccardi, 2002; Perlmutter, 2010; Sujetovienė & Galinytė, 2016; Washburn & Culley, 2006).

Our previous research showed the assessment of the air quality in Kuršumlija by lichen indication (Ristić, Kosanić, Ranković, & Stamenković, 2017). The urban area of Kuršumlija includes all of the three lichen indication zones: "lichen desert zone", "struggle zone", and "normal zone". The ''lichen desert zone'' covers a small part of this area, primarily the socially active city center, which is under an intense anthropogenic impact. The "normal zone" of lichen indication of air quality in Kuršumlija covers peripheral parts of the city. Prolom Spa is located southeast of Kuršumlija at a distance of 23 kilometers, so more detailed analyses could confirm a real possibility that the "normal zone" of lichens in Kuršumlija is continuously connected to the "normal zone" in Prolom Spa.

Different air pollution levels in the investigated area is a logical consequence of air pollution and the mutual influence of microclimate, substrate and geophysical features, as well as the distribution of areas and objects. The only cause of air pollution in the town of Kuršumlija is relatively developed motor traffic in the downtown and individual residential combustion sources.

Similar results have been obtained in the town of Blace, which belongs to same part of the country with a similar geographically morphological position. The research of the air quality on the territory of this city, which used lichens as bioindicators, indicated the presence of the "lichen struggle zone" and "lichen desert zone", whereas the "normal zone" was present only in rural areas around the city of Blace (Stamenković et al., 2013).

Conclusion

A research on biological indication of air quality was conducted for the first time in the area of Prolom Spa using lichens as bioindicators. The *IAP* value calculation method is widely accepted as an appropriate method for the air quality analysis. According to the calculated *IAP* values ranged between 40 and 56, most part of the investigated area belongs to the lichen "normal zone". The use of lichens with the aim of indicating air quality showed that the air in the investigated area was of good quality. *IHI* values show that there is an anthropogenic impact on the investigated area. Traffic density and individual household heating are possible sources of air pollution. Such anthropogenic influences are not so strong in this investigated area to pollute the air to such an extent. However, it is desirable to repeat such research, since the appropriate and adequate results are obtained by the continuity of successive detections, i.e. monitoring.

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Appendix

Table A1
Lichen taxa, the value of coefficient f, frequency (%), IAP and IHI values at investigated points in Prolom Spa

Taxon	Investig. point/ coeff. *f*														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Anaptychia ciliaris (L.) Körb. ex A.Massal.	1	0.4	0.4	1	0	0	0	1	0	0	0	0	0	0	0
Buelia punctata (Hoffm.) Massal.	0.4	1	0.3	1	1	1	2	1	0.4	0	0	0	1	0	1
Candelaria concolor (Diskson) Stein	0.3	0	0.3	0	0	0	0	0	0	0	0	0	0	1	0
Candelariella aurella (Hoffm.) Zahlbr.	0	0	0.3	0	0	0	0	0	0	0	0	0	1	1	0.3
Candelariella xanthostigma (Ach.) Lettau.	1	0	1	0	0	1	0	0	0	1	0	0	0	1	0
Cetraria islandica (L.) Ach.	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0
Cladonia coniocraea (Flörke) Spreng.	0	0	0	1	1	1	0	0	1	1	0	1	0	0	0
Cladonia convoluta (Lam.) Anders	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Cladonia fimbriata (L.) Fr.	0	1	0	1	0	1	0	0	1	1	1	0	0	1	0
Cladonia foliacea (Huds.) Willd.	0	1	0	1	0	1	0	0	0	0	1	1	0	0	0
Cladonia furcata (Huds.) Schrad.	0	1	0	0	0	0	0	0	1	0	0	1	0	1	0
Cladonia rangiformis Hoffm.	0	0	0	1	1	1	0	0	0	0	1	1	0	0	0
Cladonia subulata (L.) Weber ex F.H. Wigg.	0	0	0	0	0	0	0	0	0.4	1	0	0.4	0	0	0
Evernia prunastri (L.) Ach.	5	5	2	2	3	4	0	5	3	3	0	2	4	1	3
Flavoparmelia caperata (L.) Hale	4	3	2	3	4	0.4	1	4	4	3	0	3	0.4	1	2
Graphis scripta (L.) Ach.	0	0	0	0.3	0	1	1	0	0	0.3	1	0	0	0.3	0
Hypogymnia physodes (L.) Nyl.	5	4	3	3	5	2	3	4	2	3	3	2	4	1	4
Hypogymnia tubulosa (Schaerer) Havaas	2	2	2	2	1	0	4	3	2	1	2	1	1	0.4	1
Lecanora allophana (Ach.) Nyl.	0.3	1	0	0	0.4	0.4	0.3	0.3	0	0	0	0	0	0.3	1
Lecanora argentata (Ach.) Malme	0	0	0	0	0	0	0	0	0	1	0	0	0.3	1	0
Lecanora atra (Huds.) Ach.	0	0.1	0	0	0	0	0	0	0	0	0	0.3	0	0	1
Lecanora carpinea (L.) Vain	0	0	0	0.3	0.3	0	0.4	0.4	0.4	0.3	0.4	0	0	0	0.4

Table A1 (continued)

Taxon	Investig. point/ coeff. *f*														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Lecanora confusa Almb.	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0
Lecanora conizaeoides Nyl. ex Cromb.	0	0.3	0	0	0	0	0	0	0	0	0	1	0	0	0
Lecanora glabrata (Ach.) Malme	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Lecanora intumescens (Rebent.) Rabenh.	1	0	1	1	1	0	1	0	1	1	1	0.4	1	1	0
Lecanora muralis (Schreb.) Rabenh.	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0
Lecanora pulicaris (Pers.) Ach.	1	0.4	1	1	0.3	1	1	0.4	0	0	1	0.3	2	0.3	0
Lecidella elaeochroma (Ach.) Choisy	1	0.4	1	1	1	1	1	1	0.4	1	1	1	1	1	1
Lepraria incana (L.) Ach.	3	1	1	2	1	0.4	0	2	2	1	0	1	0	0	1
Melanohalea elegantula (Zahlbr.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	0	0	0	0	0	0	0	0	0.3	1	0	0	0	0	0
Melanohalea exasperata (De Not.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	0	0	1	0.4	0	0	0	1	0	0	1	0	0	1	0
Melanohalea exasperatula (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	1	0.3	0.3	0.4	1	2	0	1	1	0	1	0.3	1	1	1
Melanelixia fuliginosa (Fr. ex Duby) O.Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	0	0	0	0	0	2	0	0	1	0	0	0	1	1	0
Melanelixia glabra (Schaer.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	0	1	1	1	1	1	0.3	1	0.4	0	1	1	1	0.4	1
Melanelixia subaurifera (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	1	1	2	1	3	2	3	3	1	2	3	2	1	0	1

Table A1 (continued)

Taxon	Investig. point/ coeff. *f*														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Melanelixia subargentifera (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0
Ochrolechia pallescens (L.) Massal.	0.3	1	1	0.4	1	0.3	1	0	0	0	2	0	0.3	1	1
Parmelia saxatilis (L.) Ach.	1	0	0	0	1	0	0	0	0	0.4	0	1	0	0	0
Parmelia sulcata Taylor	4	4	3	5	3	5	4	4	2	3	3	4	6	3	5
Parmelia tiliacea (Hoffm.) Hale	1	1	1	1	0.4	3	0	1	0.3	1	0	0.4	0	1	0.3
Parmelina pastilifera (Harm.) Hale	0.4	0.3	0	1	0.3	1	1	0	0.4	1	2	1	0	0	0
Parmelina quercina (Willd.) Hale	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0
Parmeliopsis ambigua (Wulfen) Nyl.	1	0	1	0	0	0	0.4	0	0	0	0	1	0	0	0
Peltigera canina (L.) Willd.	0	1	0	1	1	1	0	0	1	1	1	0	0	1	0
Peltigera rufescens (Weiss) Humb.	0	1	0	1	0	1	0	0	1	1	0	0	0	0	0
Pertusaria albescens (Huds.) M. Choisy & Werner	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1
Pertusaria amara (Ach.) Nyl.	0	1	0	1	1	0	0	1	0	1	0	0.4	0	0	1
Physcia adscendens (Fr.) H. Olivier	2	2	3	2	2	5	2	1	1	2	3	2	5	3	3
Physcia aipolia (Ehrh. ex Humb.) Fürnr.	0.4	1	1	0.4	2	2	1	1	0	1	1	0	2	1	1
Physcia semipinnata (Leers ex J.F. Gmel.) Moberg	2	0	0	1	0	0.4	0	2	1	1	0	2	0	0	1
Physcia stellaris (L.) Nyl.	1	0.4	1	1	1	0.4	2	0.3	0.3	1	1	1	1	2	1
Physcia tenella (Scop.) DC.	1	0.3	0	0.3	0	1	0.4	0.3	1	0	1	1	1	0	0.4
Physconia deters (Nyl.) Poelt	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0
Physconia distorta (With.) J.R. Laundon	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Physconia enteroxantha (Nyl.) Poelt	0	0	0.4	0	0	2	1	1	0	0.4	1	1	0	0	0
Physconia grisea (Lam.) Poelt	1	1	1	0	1	2	1	3	1	1	0	1	1	1	0

Table A1 (continued)

Taxon	Investig. point/ coeff. *f*														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Platismatia glauca (L.) W.L. Culb. & C.F. Culb.	0	0	0	0	1	0	5	0	0	0	4	0	0	0	0
Pleurosticta acetabulum (Neck.) Elix & Lumbsch	0	0	0	0	0	0	4	0	0	0	3	0	0	1	0
Pseudevernia furfuracea (L.) Zopf	1	4	1	1	1	1	0	2	0.4	1	0	2	1	1	0
Ramalina farinacea (L.) Ach.	1	1	2	2	2	0	0	3	2	1	0	0	1	0	2
Ramalina fastigiata (Pers.) Ach.	2	1	1	2	0.4	0	0	2	1	0	0	2	0	1	1
Ramalina fraxinea (L.) Ach.	1	0.3	0.3	1	0.3	0	0	0.3	1	0	0	1	0	0	1
Rhizocarpon geographicum (L.) DC.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Rinodina colobina (Ach.) Th.Fr.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Rinodina pyrina (Ach.) Arnold	0	0	0	0.3	0	0	0	0	0	0	0.3	0	0	0	0
Usnea hirta (L.) Weber ex F.H. Wigg.	2	1	0	1	1	0.1	0	1	1	1	0	1	0	0	2
Usnea subfloridana Stirt.	0	0.3	0	0	1	0	0	0	0.4	0.3	0	0.3	0	0	0
Xanthoparmelia conspersa (Ehrh. ex Ach.) Ach.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Xanthoparmelia somloënsis (Gyeln.) Hale	0	0	0	0	1	1	0	0	0	0	0	1	0	1	0
Xanthoria parietina (L.) Beltr.	0.4	0.3	3	2	1	3	2	1	2	2	0	2	3	3	1
Index of atmospheric purity (*IAP*)	50	48	43	52	53	55	45	55	43	45	45	49	45	40	43
Index of human impact (*IHI*)	14	10	24	14	12	12	12	14	8	16	16	18	14	14	18