PRELIMINARY STUDY ON EPIPHYTIC LICHENS AS AN INDICATOR OF ENVIRONMENTAL QUALITY IN FORESTS FROM AROUND BUCHAREST MUNICIPALITY (ROMANIA)

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Abstract. The epiphytic lichens were investigated for three forests situated around Bucharest Municipality. The comparative historical background studies concerned with epiphytic lichens in relation to environmental conditions were related. Five variables close related with the distance was analysed within this study, as follow: (1) in close correlation with the distance, the taxonomic analysis reveals a major significance regarding the dominant roll of the genera with a low epiphytic lichens diversity, within the Andronache Forest, unlike Cernica and Pustnicul Forest where, the number of genera is do not significantly owing increasing species number; (2) regarding the substrate, epiphytic lichens species from all investigated forests prefer trees with a roughly rhytidoma. Trees sampled in a great deal belong to the Quercus genus with a roughly rhytidoma facilitating a good growing of epiphytic lichens species because keeps for a long periods of time a high degree of humidity; (3) the analysis of toxi-tolerance degree has shown how the sensitive epiphytic lichens species to pollution is increasing depending on the distance; (4) autsozological categories are marked in a great deal by a great distance from an urban Bucharest area. Thus, the number of rare and disappearing lichens species is increasing direct proportional depending on the distance from the Bucharest Municipality area to investigated forests due to improvement of the environmental quality; (5) from geographical distribution of lichens species point of view, take a place an increasing number of epiphytic lichens species which is close correlated with the distance from Bucharest Municipality area to investigated forests. In addition, a great importance was conferred the presence of rare and disappearing epiphytic lichens species nearest perturbation area of Bucharest Municipality (Andronache Forest). This fact is possible to occur owing to the direction of prevailed winds. It was used of sensitivity values of epiphytic lichens species to quantify spatial gradients in environmental alteration.

Keywords: epiphytic lichen, Bucharest Municipality (Romania), environmental quality, Andronache, Pustnicul, Cernica

INTRODUCTION

Epiphytic lichens are extremely sensitive to environmental perturbations [1, 7].

The indicator term refer to the ability of an organism to indicate either presence/absence or high/low level for any pollutant factor from air [24]. Therefore, lichens are the best well-known indicators of air pollution, so that they are used to monitoring and assessment of environmental quality, on bases their sensibility [17].

Surroundings urban centres, strongly industrialized, was observed high weak air pollution, lichens epiphytic vegetation being diminished or totally disappeared (lichen desert) [2, 12].

The abundance and diversity of lichens flora are close correlated with the environmental conditions [27]. Thus, the number of lichens species is increasing direct proportional with the distance from the main pollution sources [4, 13].

The urban sources pollution induces changes on environmental quality to reflect in modifications of the lichen flora composition and on their morphologically aspects (lichens thalii are bleached, deformed, or reduced in size) [5, 14].

By moving, the industrial sources from Bucharest Municipality to peripheral areas or to variables distances from it and close correlated with the existence of the industrial parks (Metav Industrial Park, Sema Industrial Park, Bucharest Industrial Park and Faur Industrial Park) within Bucharest Municipality contribute to affecting large geographical area around Bucharest Municipality [8]. This fact has extremely negative effects on biodiversity, especially on lichens.

Forests around Bucharest Municipality have been subjected to on long-term the processes of fragmentation and deterioration leading to the decline of lichens communities [1, 16, 19].

The present investigation, performed within three forests from around Bucharest Municipality, aims to knowledge the environmental quality using epiphytic lichens diversity. Increasing epiphytic lichen diversity depending on the distance is shown.

The present note is an integrated part of an extensive study within PhD Thesis.

MATERIALS AND METHODS

Studied area

The investigated area is a part of the East Muntenia Plain. This is the youngest sector of the Romanian Plain, displays three steps parallel to the Sub Carpathians and the Danube. The contact with the Sub Carpathians is represented by a piedmont plain, alluvial fans and glacis made of gravels, sands, clays and marls with deltaic bedding. The subsidence plain extends as a continuous strip between the Argeş and the Siret rivers. It marks the recession of the Quaternary Lake, and has two wider sectors: between the Argeş and the Ialomița and between the Prahova and the Sărata. In these areas the rivers are strongly diverging. The third strip, of tabular plain, is the largest and has loess-covered, non-fragmented flat interfluves with a wealth of crovs. On the righthand side of the Călățui and the Ialomița, vast grounds with fixed dunes are visible [6].

From climatic factors of view the studied area is characterized, as follow:

The solar radiation is 125.39 kcal/cm^2 on the horizontal surface, the maximum value of insolation records in July (18.33 kcal/cm^2 at Bucharest-Filaret and 18.21 kcal/cm^2 at Bucharest Afumați), and the

minimum value records in December (3.040 kcal/cm^2) [15].

The annual mean of the air temperature (calculated for periods 1961-2000) records values range between 9.8 °C at Tâncăbeşti and 11.2°C both Giurgiu and Bucharest-Filaret [15].

The air humidity has annual mean values variable depending on the type of the active surface, the distance from aquatic and forestry ecosystems, and the regime of pluviothermic and of the evapotranspiration. The multiannual values of air humidity range between 75% and 80%. Under the impact of thermal pollution the air humidity is low especially in that zone with a greatest density of buildings [15].

Precipitation is one of the most important meteorologically parameter in evaluation of the atmosphere quality. Annual mean precipitation values decrease from North (613.1 mm) to South (550 mm) of the Bucharest Municipality. The high values of precipitation in the North part of Bucharest Municipality determine the transfer of pollutants from air and topographic surface to aquatic systems [15].

The winds influence direct the dispersion of the pollutants in atmosphere. The prevailing winds are those from North-East (22.4% at Băneasa, 23.2% at Afumaţi) and from South-West (14.8% at Băneasa, 8.1% at Afumaţi respectively) [15].

The characterization of the vegetation from investigated area

The vegetation within the investigated area is represented by the sylvo-steppe zone with a strong Submediterranean influences, being characterised by the substantial presence of two southern oak species, the pubescent oak (*Quercus pubescens*), a typically Submediterranean element, and *Quercus pedunculiflora*, a Pontic element. Oriental hornbeam (*Carpinus orientalis*) and tartarian maple are also frequently found. There is a wealth of undergrowth bushes and the herb cover shelters Submediterraneand continental Eurasian species. Various oak species (*Q. cerris, Q. frainetto, Q. pubescens* and occasionally *Q. robur*) often occur in assotiation with hornbeam, lime and elm trees. This forest-steppe type, with a lot of local varieties, is widespread in the Romanian Plain [6].

Particularly the forest around Bucharest Municipality are caracterised by prevailing *Q. cerris* and *Q. farnetto* [23] and is represented by following vegetal assotiation: *Lychnio coronariae-Quercetum cerris* Sanda & al. 2003 (Syn.: *Quercetum cerris* Georgescu 1941 *geticum* Pop 1967; *Quercetum farnetto-cerris* Georgescu 1945, Rudski 1949) cited to Pustnicul Forest; *Tilio tomentosae-Carpinetum betuli* Doniţă 1968 (Syn.: *Querco petraeae-Carpinetum* auct. transs.; *Tilio tomentosae-Carpinetum degradatum* Dobrescu & Kovács 1973) cited to Cernica Forest and *Melico uniflorae-Tilietum tomentosae* (Sanda & Popescu 1971) corr. Popescu & Sanda 1992 (Syn.: *Tilietum tomentosae* Sanda & Popescu 1971) established to Andronache Forest [25, 26].

From lichen flora point of view, the forest around Bucharest Municipality did not intensive study. Were pointed out sporadic data regarding lichen species within Andronache and Cernica Forests [21]. Also, was performed a study on lichen flora from Pustnicul Forest [18].

The characterisation of the environmental quality from Bucharest Municipality

Bucharest Municipality is the capital of Romania being the largest and the most important political, economic, financial-banking, commercial, transport, cultural-scientific, educational, information, sporting and tourist centre. The city is lies in the south-south-east of Romania, in the Vlăsia Plain and is crossed by the Dâmboviţa and the Colentina rivers. It is intersected by Parallel 44°25'50'' N latitude and Meridian 26°06'50'' E longitude. The Municipality of Bucharest (1.926.354 inhabitants in 2002) covers 228 km^2 (0.1% of Romania's surface-area) and is divided in six administrative sectors according to a concentrically pattern [6].

The quality of air in Bucharest Municipality is mainly influenced by industrial activities especially power stations, vehicular traffic, domestic heating, offal's, construction activities, etc. A strongly impact on air quality have a few industrial platforms, as follow: Pantelimon Platform that releases in atmosphere suspended and sedimentable particulate matters, and SO_2 (sulphur dioxide); Dudeşti-Policolor that emits in atmosphere airborne, Pb (lead), NO_x (nitrogen oxides), NH_3 (ammonia), and volatile organic compounds; Faur-Republica, this source emits in the atmosphere airborne, sedimentable matters, SO_2 (sulphur dioxide), and NO_x (nitrogen oxides); Grivita emits in the atmosphere airborne and sedimentable matter; Militari emits in the atmosphere formaldehyde, CO (carbon monoxide), airborne; and Jilava that releases in the atmosphere airborne, NO_x (nitrogen oxides), and organic compounds [15].

An extreme strongly impact on air quality is represented by power stations, responsible up to 76% of SO_2 emissions, 36% of NO_x, and 70% of CO_2 (carbon dioxide). By a high volume of emissions are remarked Power Station South, Power Station West, and Power Station Progresul [15].

Another important source of pollution in Bucharest Municipality is represented by vehicular traffic that is responsible up to 90% of CO emissions, 59% of NO_x, 45% volatile organic compounds, and 95% lead emissions. The lead concentrations range between 0.22 µg/m^3 at Cercul Militari and Mhai Bravu, 0.18 µg/m^3 at Berceni and 0.66 µg/m^3 at Baloteşti, these values do not exceed the maximum concentration annual accepted, but are sporadic exceeded these values. In Brăneşti zone, the lead emissions from industrial units have determined arising of health problems at population level, in 2004, were pointed out by Ilfov Public Health Direction a number of 15 patients with saturnine poisoning [15].

Sampling procedure

In the researched area, the lichens species was inventoried within following forests: Andronache, Cernica, and Pustnicul, all investigated forest are situated in the North and North East part of Bucharest Municipality (Fig. 1).

Legworks were performed during March-August, 2009. Procedure of researching has consisted in random selected up to six sampling units of 4 x 4 m within each investigated forest. Within sampling units, all trees were sampled. Epiphytic lichens species have been collected beginning from the basis of the trunks to the height of to 2.5 m. The lignicolous lichens species were taken into account.

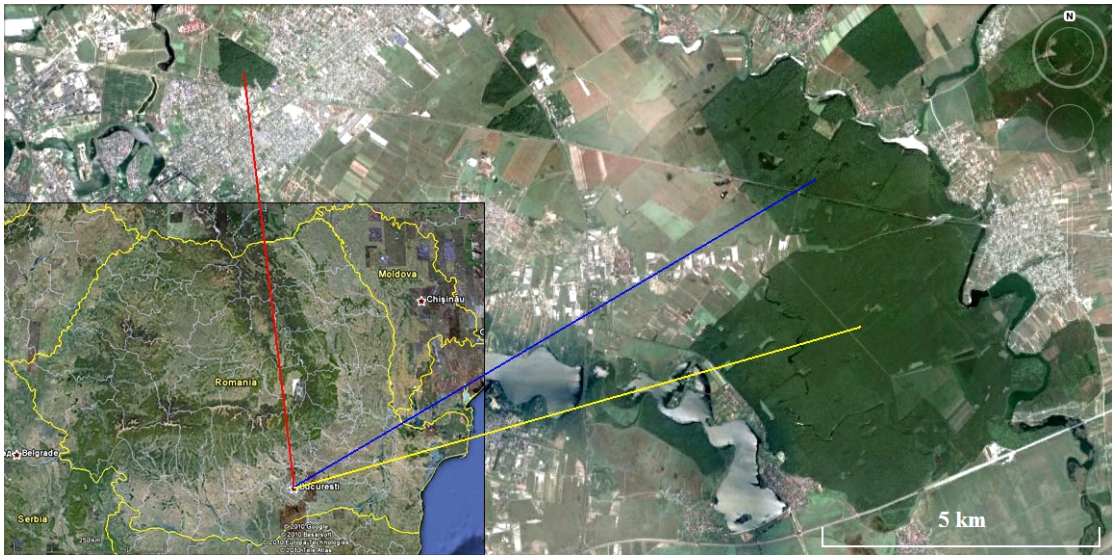

Figure 1. Andronache Forest (marked with a red colour arrow on map), Cernica Forest (marked with a yellow colour arrow on map) and Pustnicul Forest (marked with a blue colour arrow on map). The mentioned forests are situated from geographical point of view near Bucharest Municipality. Source: this is an own construct map by Google Earth software.

Surveying samples

Collected lichens species were carried into laboratory to be determined using the bibliography [9-10, 22]. All lichens species were investigated with a stereomicroscope and an optical microscope. Lichens species were identified based on colour reaction of the thallus, morphology, aspects of thlline elements, microscopically preparation by using chemical reagents such as KOH, $CaCl_2$, and IIK. The nomenclature used is according to Ciurchea [10].

The ecological behaviour (toxi-tolerance degree and the frequency of investigated lichens species) was characterised using data within bibliography [11-28].

The disappearing lichen species have been considered according to bibliography [11-28], as almost disappeared or nearly everywhere markedly disappearing (endangered lichens species).

The lichen species is a part of Lichen Collection of Institute of Biology, Romanian Academy from Bucharest.

RESULTS

In the investigated area have been identified 22 lichens species, of which a largest percentage was recorded within Pustnicul Forest (47% lichen species), followed by Cernica Forest (29% lichen species) and Andronache Forest (24% lichen species) (Fig. 2). From a total number of lichens species within Pustnicul Forest, 50% are cited for the first time.

Taxonomic analysis (Table 1)

From taxonomic point of view, the lichen species are tabulated in two Orders, namely: Lecanorales with a few Family (Physciaceae, Candelariaceae, Parmeliaceae, Lecanoraceae, and Ramalinaceae) and, Teloschistales with one Family (Teloschistaceae).

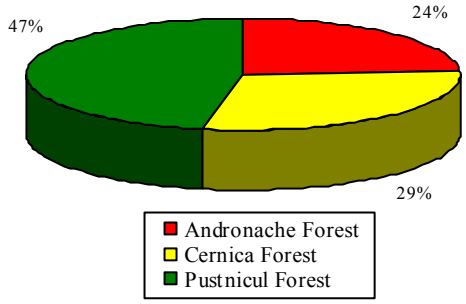

Figure 2. The spectrum of lichens species distribution in relation with investigated forests.

Substrate

In all investigated forests the prevailing tree species belong in a great deal to Quercus genus, following by species such as: *Fraxinus excelsior*, *Prunus cerasifera, Sophora japonica, Acer campestre, Cornus sanguinea,* and C*rataegus monogyna*.

Toxi-tolerance degree (Table 2)

The percentage of lichens species, which are sensitive to pollution, is increasing with the distance from Bucharest Municipality. The highest percentage of the sensitive lichens species was recorded in Pustnicul Forest (39% sensitive lichens species). Both in Cernica Forest and especially in Andronache Forest, the percentage of sensitive lichens species is rather low (27% lichens species and 22% lichens species, respectively).

The percentage with a high and moderate resistance to pollution in generally it is decreasing direct proportional with the distance from Bucharest Municipality (Table 2).

Table 1. Taxonomic arrangement of lichens species in relation with the investigated forests and the substrate.

Species	Taxonomic classification	Locality					
		Andronache	Substrate	Cernica	Substrate	Pustnicul	Substrate
Candelaria concolor (Dicks.) Poelt.	Ascomycotina Gymnocarpeae Lecanorales candelariaceae	+	*Quercus robur*	+	*Quercus robur*	+	*Fraxinus excelsior*
Lecanora hagenii (Ach.) Ach.	Lecanoraceae	N/A	N/A	N/A	N/A	+	*Q. cerris*
Lecanora subintricata (Nyl.) Th. Fr.	Lecanoraceae	N/A	N/A	N/A	N/A	+	*Q. cerris*
Hypotrachyna sinuosa (Sm.) Hale	Parmeliaceae	N/A	N/A	N/A	N/A	+	*Q. cerris*
Melanelia olivacea (L.) Essl.	Parmeliaceae	N/A	N/A	N/A	N/A	+	*Q. cerris*
Parmelia sulcata Taylor	Parmeliaceae	+	*F. excelsior*	N/A	N/A	+	*Q. cerris*
Buellia erubescens Arn.	Physciaceae	+	Quercus sp.	N/A	N/A	+	*Q. cerris*
Phaeophyscia nigricans (Flk.) Moberg.	Physciaceae	+	*F. excelsior*	+	N/A	+	*Cornus sanguinea*
Phaeophyscia orbicularis (Nëck.) Moberg.	Physciaceae	+	*Q. cerris, F. excelsior, Prunus cerasifera, Sophora japonica*	+	*lignicolous*	+	*lignicolous*
Physcia adscendens (Fr.) Oliv.	Physciaceae	+	*Q. cerris, F. excelsior, C. monogyna, S. japonica, Acer campestre, Q. robur*	+	*Q. cerris, lignicolous*	+	*Q. cerris, lignicolous*
Physcia aipolia (Ehrh. ex Humb.) Fürnr	Physciaceae	N/A	N/A	+	*lignicolous*	N/A	N/A
Physcia semipinnata (J. F. Gmelin) Moberg.	Physciaceae	N/A	N/A	N/A	N/A	+	*Q. robur*
Physcia stellaris (L.) Nyl. em. Harm.	Physciaceae	N/A	N/A	+	*Q. robur*	+	*Q. robur*
Physcia tenella (Scop.)	Physciaceae	+	*F. excelsior, P. cerasifera*	+	*Q. cerris*	+	*Q. cerris, Q. robur, P. cerasifera*
Physcia tribacoides Nyl.	Physciaceae	N/A	N/A	+	*lignicolous*	N/A	N/A
Physconia detersa (Nyl.) Poelt.	Physciaceae	+	*A. campestre, Q. robur*	N/A	N/A	+	*Lignicolous*
Physconia distorta (With.) J. R. Laudon	Physciaceae	N/A	N/A	+	*lignicolous*	+	*Lignicolous*
Physconia grisea (Lahm.) Poelt.	Physciaceae	+	*P. cerasifera*	+	*lignicolous*	N/A	N/A
Ramalina farinacea (L.) Ach.	Ramalinaceae	N/A	N/A	N/A	N/A	+	*Q. cerris*
Ramalina pollinaria (Westr.) Ach.	Ramalinaceae	N/A	N/A	N/A	N/A	+	*Q. cerris*
Lepraria finkii (B. de Lesd. ex Hue) R Harris	N/A	N/A	N/A	N/A	N/A	+	*Q. cerris*
Xanthoria parietina (L.) Th. Fr.	Teloschistaceae	N/A	N/A	+	*Q. cerris, lignicolous*	+	*Q. cerris, lignicolous*

Legend of the table: + presence of the species; N/A: not available

Table 2. Toxi-tolerance degree of lichens species in relation with the investigated forests.

Forest investigated					
Andronache		**Cernica**		**Pustnicul**	
Toxi-tolerance degree	Species number (%)	Toxi-tolerance degree	Species number (%)	Toxi-tolerance degree	Species number (%)
sensitive species to pollutions	22%	sensitive species to pollutions	27%	sensitive species to pollutions	39%
moderately resistance species to pollutions	33%	moderately resistance species to pollutions	37%	moderately resistance species to pollutions	28%
high resistance species to pollutions	45%	high resistance species to pollutions	36%	high resistance species to pollutions	33%

Frequency of lichens species (Table 3)

The results regarding the rare lichens species indicate a lowest increasing of these depending of the distance from 44% in Andronache Forest to 50% in Pustnicul Forest and 55% in Cernica Forest, respectively. The assessment of the disappearing lichens species have been focused on basis the correlation between the bibliography data [11-28], as almost disappeared or nearly everywhere markedly disappearing (threatened with disappearance), especially because of pollution, and by own observations regarding the presence of these rarest lichen species in all investigated forests. Thus, did not record significantly variations regarding the percentage of these, recording in a great deal lowest values within all investigated forests (Table 3).

The percentage of common lichens species did not vary significantly within the investigated forests, recording a lowest decreasing as a function of the distance from 45% in Andronache Forest to 39% in Pustnicul Forest and 36% in Cernica Forest respectively (Table 3).

In addition, there is a close correlation between the percentage of common lichens species and the anthropogenic pressure within the researched area.

Table 3. Frequency of lichens species in relation with the investigated forests.

Forest investigated					
Andronache		**Cernica**		**Pustnicul**	
Frequence	Species number (%)	Frequency	Species number (%)	Frequence	Species number (%)
Rare species	44%	Rare species	55%	Rare species	50%
Disappearing species	11%	Disappearing species	9%	Disappearing species	11%
Common species	45%	Common species	36%	Common species	39%

DISCUSSIONS

Comparisons with other similar studies

Environmental quality indicated by epiphytic lichens diversity can be appreciated when it is compared with other similar studies on epiphytic lichens. Within the studied area were recorded a total of 22 lichens species on rhytidoma of sampled trees within sampling units. In the urban, suburban and rural Bucharest area were performed researches on epiphytic lichens focused on lichens species number in relation with ecological conditions. Thus, in Mogoşoaia Forest [19], were cited 53 lichens species of which following lichens species are common with these from actual studied area: *Melanelia olivacea*, *Candelaria concolor*, *Xanthoria parietina*, *Physcia aipolia*, *Physcia stellaris*, *Physcia tenella*, *Physcia semipinnata*, *Physcia ascendens*, and *Lepraria aeruginosa*. A great majority of these are rare lichens species, cited for that time. In a strongly contrast with a total lichens species of 18 recorded within Pustnicul Forest in 2009, in 1970 had cited 43 lichens species in the same forest [18]. In this case the common lichens species are: *Candelaria concolor*, *Parmelia sulcata*, *Ramalina farinacea*, *Ramalina pollinaria*, *Xanthoria parietina*, *Physcia aipolia*, *Physcia ascendens*, *Physconia grisea*, *Physconia distorta*, *Physcia stellaris*, *and Physcia tenella*. Of these which only following lichens species are anthrophyllous, for instant: *Parmelia sulcata*, *Xanthoria parietina*, *Physcia ascendens*, *Physcia tenella* the other species are rare species and very sensitive to pollution. This comparisons reveals on the one hand a great decreasing of lichens species since 1970 to 2009 in an increasing the environment stress conditions around Bucharest Municipality and a positive correlations between the increasing of the number of rare species as a functions of distance from Bucharest Municipality, on the other hand. It was pointed out, a similar relative study with the topic present note regarding the anthropogenic impact on epiphytic lichens in urban conditions [20]. The researches performed in Botanic Garden from Bucharest have led to identification of 29 lichens species. From number of common species in relation with species identified within present study, following species are anthrophyllous (*Physcia ascendens*, *Physcia tenella*, and *Xanthoria parietina*) and rare (*Candelaria concolor*, *Physcia semipinnata*, *Physconia detersa*, *Physconia grisea*, *Physcia stellaris*) lichens species, respectively. The literature studies were selected to comparing actual data on basis geographically and climatic considerations specific Romanian Plain. A comparison to these other mentioned forests, the investigated area has a lower number of epiphytic lichens.

Similar studies were performed abroad concerning environmental quality in relation with epiphytic lichens diversity [7]. Within this study, the investigated area

(Knocksink Wood in County Wicklow, Ireland) in relation to other woodland sites had a lower number of epiphytic lichens. The diversity of epiphytic lichens at Knocksink Wood is driven by multitude environmental factors, which influence it, for instant: air quality, past woodland management practices, contemporary human impacts, etc. Also, in a comparison for a period of time since 1986 to 1997 was registered disappearance of lichens at some locations from Izmir town (Turkey) indicate a worsening environmental quality between mentioned periods of time [27]. Investigations regarding a comparative study in an area situated around the Tábor town, South Bohemia (Czech Republic) were showing how in generally during 18 year the number of lichens species especially sensitive species was progressively decreasing strongly correlation with a weakest environmental quality [17].

Within the oldest Vlăsia forests the management woodland practices by fragmentation have exerted negative effects on epiphytic lichens growing on especially oak trees species [19]. Although epiphytic lichens depend primarily upon the host tree species and its properties, stand age and spatial-temporal continuity are considered key factors for the development of highly complex lichen assemblages in forests [16, 19]. This is a prove of actual situations regarding the poverty stricken of lichens flora in woodland sites investigated from round Bucharest Municipality.

Taxonomic analysis

Depending on the distance, the taxonomic analysis pointed out the marked roll of the genera frequency (26%) within the Andronache Forest slightly different by a lower percentage of lichens species (24%) with a strongly sinanthropic character, given by the dominant presence of the anthrophylous lichens species, for instant: *Physcia adscendens, Physcia tenella, Parmelia sulcata,* and *Phaeophyscia orbicularis*. The genera frequency importance of the epiphytic lichens species decreasing within the Cernica (22%) and Pustnicul (52%) forests, growing the number of lichens species with a high sensitive degree, such as: *Lecanora subintricata, Hypotrachina sinuosa, Melanelia olivacea, Phaeophyscia nigricans, Physcia tribacoides, Physconia detersa, Physconia distorta,* and *Physcia semipinnata*. The unexpected result regarding a higher genera frequency in a contrast with the percentage of lichens species within the Pustnicul Forest is given by the fact that a great majority of lichens genera support only one species. For to continuing the reasoning has to be taken into account the comparative situation between the periods of 1970-2009. A relative similarly situation was described around Zlatna town [3].

Substrate

Concerning the substrate a major roll has the composition of trees species consist in a great deal by Quercus genus according to forests typology of Vlăsiei forests. The nature of the substrate influence epiphytic lichens diversity [7].The sampled trees have a roughly rhytidoma allowing lichens species to colonisation them. This it is possible because the roughly rhytidoma retains a high degree of humudity for a long time. A great majority of thalii which growing on rhytidoma on trees surveyed especially within the Andronache Forest were deformed, reduced in size, and in a soredial accentuate state. These all aspects could be attribute to worsening environmental quality [16].

Toxi-tolerance degree

The analysis regarding the toxi-tolerance degree reveals two important aspects: an increasing of sensitive species from 22% to 39% positive correlated with the enhancing of the distance from 5.5 Km (Andronache Forest) to 15 Km (Pustnicul Forest) and an decreasing of species with a high resistance to pollutions from 45% to 33% as a function of the distance from Andronache Forest to Pustnicul Forest (Table 2). The lichens species with a moderately resistance to air pollutions were recorded a lower percentage in Pustnicul Forest (28%).

The analysis of frequency of the investigated lichens species especially of the autsozological categories

The analysis of the variables taken into account indicate that the environmental quality based on a large number of sensitive epiphytic lichens species on the one hand and rare and disappearing epiphytic lichens species on the other hand, is becoming more and more improved depending on the distance from polluted area of Bucharest Municipality. This fact is confirmed within Cernica and Pustnicul Forests by the rather high number of rare (55% and 50% respectively) and disappearing (9% and 11% respectively) lichens species on the one hand, and based on the highest number of sensitive lichens species to pollutions on the other hand. The common lichens species have recorded a lowest decreasing as a function of the distance from Andronache Forest to Cernica and Pustnicul forests. This fact might be correlated with the intensity of antropic activities within surveyed area. (Table 2 & 3).

Geographical distribution of lichens species diversity

Regarding the geographical distributions was observed a positive correlation among lichens species diversity depending on the distance. Thus, take a place an increasing of lichens species diversity from point 5.5 km where is situated Andronache Forest with a low lichens species diversity (marked by a 24% lichens species) to 14 km (Cernica Forest with a 29% lichens species) and 15 km (Pustnicul Forest where was recorded 47% lichens species) respectively with a more great lichens species diversity (Fig. 2 & 3).

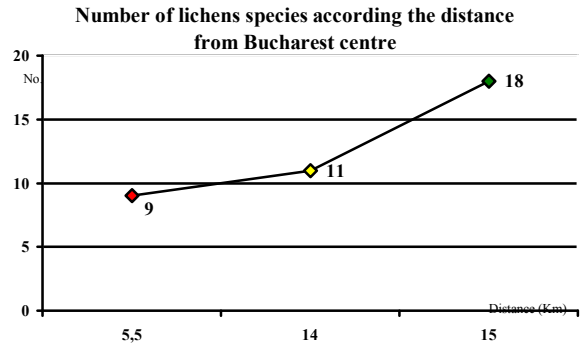

Figure 3. Lichens species number in relation with the distance from the Bucharest centre to investigated forests.

At the national level, but in a different geomorphology conditions, were performed studies regarding the increasing the number of lichens species depending on the distance correlated with the improvement of environmental conditions [4].

The particularly characterization of the rare and disappearing lichens species in Andronache Forest depending on prevailing winds

A great importance was conferred of the presence of the rare and disappearing lichen species in relation with toxi-tolerance degree within the Andronache Forest. Thus, there are three way to expression of lichens reaction from environmental conditions: (1) two lichens species, *Buellia erubescens* and *Candelaria concolor* are rare species but with a moderately resistance to pollutions; *Physconia detersa* is a disappearing species and it have a sensitivity to pollutions; and (3) *Physconia grisea*, although it is a rare species, it have a high resistance to pollutions. Probable these may be explanations by the following fact namely, the prevailed winds which blow from the North and North-East direction. In Romania studies concerning with the effects of prevailing winds strongly correlated with the distance was carried out in a few belts situated around Zlatna town [3].

The Andronache Forest is situated from geographical point of view, in the North part of Bucharest Municipality. This fact facility the carrying of a large amount of pollutants from North part of Bucharest Municipality to South and South-West part of Bucharest Municipality.

A similar situation there is in the case among the two forests (Cernica and Pustnicul Forests) situated in the North-East part of Bucharest Municipality. In these cases, it is possible that the prevailed winds in close relation with the distance contribute to cleaned air facility developing and growing a large number the rare and disappearing lichens species.

Within this study to distinguish, two major zones which reflect the distribution of the lichens diversity. One of them is suburban zones (Andronache Forest) with a low lichens diversity and a rural zone (Cernica and Pustnicul Forests) with a moderately lichens diversity. The suburban zone correspond with a low quality of environment correlated with a low lichens diversity at a distance by 5.5 km from Bucharest Municipality and the quality of environment is becoming more and more improved in relation with the increasing of the distance, the lichens diversity being intermediate. The analysis regarding the comparative situation of two variables studied, emphasize a close correlation between a low lichen diversity (Andronache Forest) nearest Bucharest Municipality and progressive this enhance from a rather intermediate (Cernica Forest) to a intermediate lichen species diversity (Pustnicul Forest).

At the European level were studied the anthropogenic impacts on lichens diversity in Province Ancona (Marche region), on the Adriatic coast of Italy, revealing a positive correlation on the one hand between the environmental quality progressive improved areas with a high lichen diversity. In the Ancona town area, on the other hand there is lichen desert caused by emission sources of pollution [12].

Within the Pustnicul Forest have recovered 50% of new lichens species (*Lecanora hagenii*, *Lecanora subintricata*, *Hypotrachina sinuosa*, *Melanelia olivacea*, *Buellia erubescens*, *Phaeophyscia nigricans*, *Phaeophyscia orbicularis*, *Physcia semipinnata*, *Physcia tribacoides*, and *Lepraria finkii*) in relation with data provided in the bibliography [18].

REFERENCES

[1] Asta, J., Erhardt, W., Ferretti, M., Fornasier, F., Kirschbaum, U., Nimis, P.L., Purvis, O.W., Pirintsos, S., Scheidegger, C., Van Haluwyn, C., Wirth, V., (2002): European Guideline for Mapping Lichen Diversity as an Indicator of Environmental Stress, London, The British Lichen Society, pp. 3.

[2] Atanasiu, L., (1971): Lichenii. Natura, 1, Anul XXIII, pp. 38-51.

[3] Bartók, K., (1985): Cartarea poluării atmosferice pe baza sensibilității lichenilor. Contribuții Botanice, Cluj-Napoca, pp. 51-57.

[4] Bartók, K., (1980): Influența poluării atmosferice asupra florei lichenologice din zona industrială a Zlatnei. Contribuții Botanice, Cluj-Napoca, pp. 195-199.

[5] Bartók, K., Crişan, F., (2007): Current level of knowledge on lichens involved in environment protection in polluted areas of Romania. Studia Universitatis, Babeş-Bolyai, Ambientum, 1(1-2), Cluj –Napoca, pp. 1-14.

[6] Bălteanu, D., Badea, L., Buza, M., Niculescu, G., Popescu, C., Dumitraşcu, M., (2006): Romania space, society, environment, The Publishing House of the Romanian Academy, Bucharest, 384 p.

[7] Brodeková, L., Gilmer, A., Dowding, P., Fox, H., Guttová, A., (2006): An assessment of epiphytic lichen diversity and environentalquality in Knocksink Wood Nature Reserve, Ireland, Biology and environment: Proceedings of the Royal Irish Academy, 106B (3): 215-223.

[8] Cepoiu, A.L., (2009): Procese industriale recente şi efectele asupra poluarii mediului. Studiu de caz: Municipiul Bucureşti. INCD ECOIND-Simpozion International-SIMI 2009 „Mediul şi Industria", pp. 242-247

[9] Ciurchea, M., (1998): Lichenii din România, Ascomycotina: Pyrenocarpi, Vol. I, Presa Universitară Clujeană, Cluj-Napoca, 333 p.

[10] Ciurchea, M. (2004): Determinatorul lichenilor din România, Bit, Iaşi, 488 p.

[11] Ellenberg, H., Weber, H. E., Düll, R., Wirth, V., Werner, W., Paulißen, D., (1992): Indicator value of plants in Central Europe, Erich Goltze KG, D-3400 Göttingen, 258 p.

[12] Frati, L., Brunialti, G., (2006): Long-term biomonitoring with lichens: comparing data from different sampling procedures, Environmental Monitoring and Assessment, Springer, doi: 10.1007/s 10661-005-9032-5, 119: 319-404.

[13] Györkös, L., Bartók, K., (2006): Diversity, distribution and ecology of the lichens in the Aiud town area (Alba County). Contribuții Botanice, Anul XLI, 1: 13-22.

[14] Hauck, M., (2008): Epiphytic lichens indicate recent increase in air pollution in the Mongolian capital Ulan Bator. The Lichenologist, British Lichen Society, doi: 10.1017/S0024282908007561, 40(2): 165-168.

[15] Iojă, C., (2008): Metode şi tehnici de evaluare a calității mediului în aria metropolitan a Municipiului Bucureşti, Editura Universității din Bucureşti, Bucureşti, 260 p.

[16] Jüriado, I., Liira, J., Paal, J., (2009): Diversity of epiphytic lichens in boreo-nemoral forests on the North-Estonian limestone escarpment: the effect of tree level factors and local environmental conditions. The lichenologist, British Lichen Society, 41(1): 81-96.
[17] Liška, J., Herben, T., (2008): Long-term changes of epiphytic lichen species composition over landscape gradients: an 18 year time series, The Lichenologist British Lichen Society, doi: 10.1017/S0024282908006610, 40(5): 437-448.
[18] Moruzi, C., Klohs, D., (1970): Contribuţii la flora lichenologică a Pădurii Brăneşti. Analele Universităţii din Bucureşti, Biologie vegetală, 19: 9-11.
[19] Moruzi, C., Mantu, E. (1965): Lichenii corticoli gymnocarpi din Pădurea Mogoşoaia. Comunicări de Botanică, 8: 195-205.
[20] Moruzi, C., Petria E. (1961): Lichenii corticoli şi saxicoli din Grădina Botanica din Bucureşti.Lucrările Grădinii Botanice din Bucureşti, Acta Botanica Horti Bucurestiensis, Bucharest, pp: 261-271.
[21] Moruzi, C., Petria, E., Mantu, E. (1967): Catalogul lichenilor din România, Lucrările Grădinii Botanice din Bucureşti, Acta Botanica Horti Bucurestiensis, Bucharest, 389 p.
[22] Moruzi, C., Toma, N., (1971): Lichenii, Determinator de plante inferioare, Didactică & Pedagogică Publisher, Bucharest, 221 p. + 45 figures.
[23] Paşcovschi, S., Leandru, V., (1958): Tipuri de pădure din Republica Populară Română, Agro-Silvică de Stat Publishing House, Bucharest, pp: 104.
[24] Rusu, A.M., Bartók, K., Purvis, W., Dubbin, B., (2001): Bioindicarea cu ajutorul lichenilor a gradului de poluare în zona industrială Zlatna. Studii şi cercetări (Biologie), Bistriţa, 6: 45-48.
[25] Sanda, V., Popescu, A., (1971): Cercetări fitocenologice în pădurile din jurul Bucureştiului, Studii şi cercetări de Biologie, Seria Botanică, 23(2): 125-142.
[26] Sanda, V., Vicol, I., Ştefănuţ, S., (2008): Biodiversitatea ceno-structurală a învelişului vegetal din România, Ars Docendi Publisher, Bucharest, 569 p.
[27] Sommerfeldt, M., John, V. 2001. Evaluation of a method for the reassessment of air quality by lichen mapping in the city of Izmir, Turkey, Turkish Journal of Botany, 25: 45-55.
[28] Wirth, V. (1995): Flechtenflora, Verlag Eugen Ulmer Stuttgart, 663 p.

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