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CONTRIBUTIONS TO THE STUDY OF LICHENS IN THE REPUBLIC OF MOLDOVA AND THEIR APPLICATION IN AIR QUALITY MONITORING

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Abstract: Currently, the lichen flora of the Republic of Moldova comprises *c.* 200 species and varieties, of which 22 species are reported nationally for the first time and 40 species are recommended as reliable indicators. The paper presents a Lichens Toxi-tolerance Scale (LTS) towards SO_2 concentration in the air. An air quality assessment scale with 6 gradations (further referred to as AQAS) is proposed, taking into account the specific diversity, abundance and indicator species toxi-tolerance. The proposed scale has been applied to 62 forest ecosystems. The paper also presents a comparative analysis of the application of AQAS towards EMEP data for the Republic of Moldova.

Keywords: lichens, new species, forest ecosystems, lichen indicator, air pollution, SO_2 emissions, toxi-tolerance, abundance, evaluation criteria, European programme EMEP, environmental monitoring.

Introduction

The lichen flora of the Republic of Moldova has been studied sporadically over the past 75 years. Most of the publications concerned epiphyte species inhabiting natural reserves and forest ecosystems located in the central part of the country. These type of ecosystems cover a rather small part (*c.*11%) of the territory and are subject to heavy local and trans-boundary anthropogenic impact. Most lichens are extremey sensitive to increased concentrations of SO_2, NO_x and other gases: the damage is reflected in reduced photosynthesis, necrosis and even thallus destruction. Therefore, lichens are extensively utilized in monitoring environmental quality, particularly in forest ecosystems. The bio-indication method provides information on environmental quality fluctuations in time and space, synergistic effects of some abiotic factors and the response of living organisms to environmental changes.

History of lichen studies in the Republic of Moldova

The first scientific information on lichens in the Bessarabia region was published by Vrabie [48], an agriculture engineer working as an assistant to the National Museum of Natural History in Chişinău. Encouraged by the Museum’s director, he investigated lichen species density within five habitats around Chişinău: the oak forests of Durleşti and Căpriana, plum orchards in Valea Dicescu and near Ghidighici, and *Sophora* sp. trees along the Cricova School Road. He revealed some 200 individuals belonging to 30 lichen species and provided a description of 25 species and 5 varieties, with 3 species remaining unidentified. The purpose of his research was to assess the density and geographical orientation (16 cardinal directions) of lichens on tree trunks. The author concludes that lichen species density is almost uniform on cardinal directions, except the isolated *Sophora* trees, where 7 lichens species had the highest (49,2%) and lowest (24,6%) distribution in diametrically opposite directions - NE and SW. The author explains this difference by the action of natural factors (humidity, sunlight, wind, etc.). Furthermore, the data presented in the tables and figures reveal some aspects of the air quality. The richest lichen floras were in the Căpriana and Durlesti forests (18 and 15 species, respectively), followed by the habitat at Ghidighici (14 species). The poorest lichens floras were at Chişinău, Valea Dicescu and Cricova School Road, with 7 species each. The air quality can also be assessed by the presence of species rather sensitive to pollution that cover >10% of trunks: at the Căpriana site – *Evernia prunastri* (16,3%), *Lecidea enteroleuca* (11,1%), *Physcia adscendens* (12,9%), and at the Ghidighici site – *Physcia adscendens* (15,5%). The difference in air quality between the forest habitats and those of Chişinău and Cricova, indicated by the lichens, is obvious.

Scientific investigations on lichen floras in Moldova were given a boost by the activity of G. Simonov [37, 38, 50], who studied lichen taxonomy, chorology, morpho-anatomical features, environmental groups, preferred habitats, etc. Summarizing his activity [37], he confirmed the existence of 124 lichen species (from 50 genera, 7 families and 26 orders) in the Republic of Moldova. *Lecanorales* dominate (97 spp.), with *Lecanora* (12), *Parmelia* (12), *Cladonia* (9), and *Ramalina* (7) being the main genera. The author mentioned the dominance of crustose species (59) as compared to foliose and fruticose (34); xerophytic species (69) against mezophytic (8); and photophile species (64) against sciaphile (8). This underlines the dry climate of recent decades and anthropogenic impact as being the two main factors explaining the poverty of the local lichen flora. At the same time, Simonov [37] mentioned the richness of the lichen flora in forest ecosystems (90 species) and petricolous ecosystems (35 species), both dominated by crustose species (43 and 29 species, respectively), followed by those with a foliose thallus (29 and 9 species, respectively).

Recently, the bio-indicator features of lichens have become a research subject at the National Institute of Ecology. Over 80 meadow and hill forest ecosystems were studied, targeting epiphytic lichen species, and bio-indicator species, in particular. Lichen abundance, toxi-tolerance and diversity were studied, against air quality. The results were presented in a number of works by Begu [5, 6, 7, 8, 9, 10, 11, 12, 13].

Starting in the 1960s, Mîrza & Obuh [30] performed studies on lichen diversity in the forest habitats of Călineşti, Balatina and the scientific reserve "Pădurea Domnească", mentioning 58 lichen species, of which 28 were reported for the first time in the country. Colun [17], who studied the lichens within the protected areas in the middle course of the Dniester River, mentioned 14 species, of which 4 were indicated for the first time in the country, and Obuh & Colun [34] indicated 47 species for the middle course of the Prut River, 9 of them for the first time. The contribution of Vasilenko [47] who identified 21 lichen species in the Mereneşti forest, of which 4 were reported as new for the Republic of Moldova, should also be mentioned.

All these scientific inputs (of which Professor Simonov's must be mentioned first and foremost), have contributed to the lichen register of the Republic of Moldova, which currently encompasses approximately 200 species and varieties, some of which can be used as reliable indicators of air quality.

Assessment of environmental quality through lichen indicator species

The use of bio-indicators started in the second half of the 19th century, and particularly developed as lichen indication [33], which was applied to monitor air pollution, especially sulphur dioxide as well as nitrogen oxides, ozone, fluorine, chlorine, etc.

The increased sensitivity of lichens to gases and fumes is explained by their slow regeneration, as compared to higher plants, which can renew damaged tissues rather quickly [23]. Under long-term water deficit, lichens become even more vulnerable to air pollution. Garrou & Castrogiovanni [22] explained lichen sensitivity to sulphur dioxide by the fact that the pollutant is converting chlorophyll into pheophytin, substituting one atom of magnesium with another of hydrogen.

The role of lichens as bio-indicators of air pollution in the Rocky Mountains (USA) was extensively studied by S. Simonson [39]. Possible biological responses to air pollution include chlorophyll degradation, modification in photosynthesic and respiration processes, alteration in nitrogen fixation and membrane permeability, and changes in spatial coverage, reproductive capacity and community structure.

Mihailova & Vorobeicik [29] studied the dose-effect relationship in lichens in the forests of the Middle Ural region. They found significant changes in lichen sinuzia even at a slight exceeding of background pollution levels (1,5–2,3 times). Studies in the field were undertaken by researchers of the State University of Tartu (Estonia) leaded by Trass [43, 44, 45, 46], who proposed a list of test species and a 5-grade scale for air quality monitoring. He developed the Poleotoleration Index (IP) for spatial mapping of air pollution with sulphur dioxide. Blium (1986) suggested that the elaboration of indication scales should take into consideration the sensitivity of lichens to different air pollutants (SO_2, NH_3, H_2S, CO, petrol vapors) established under laboratory conditions.

The application of lichen criteria in the assessment of air quality and mapping of urban pollution in industrial areas of Romania was considered by several authors [2, 3], [4], [18], [19], [20]; [21]; [31], [40], [41]; [42]. Outstanding research was carried out by Bartók (1980), who made an inventory of the lichen flora of the Zlatna industrial area to determine the influence of pollutants on lichen formations in different ecological niches. She revealed an area of 'lichens desert' within a radius of *c.*1 km from the source of pollution and showed a direct relationship between the frequency and growth of lichens and distance from the source. Later on, the same author [3] applied a quantitative method of mapping the intensity of air pollution based on lichens substrate coverage, frequency, abundance and tolerance, thus designating areas with different degree of pollution. Ştefănescu & Bartok [41, 42] undertook a joint research on lichen species from the Romanian industrial region of Baia Mare by mapping the intensity of air pollution. They proposed to extend the existing 3-level scale by one additional level, reflecting pollution of air from moderate to insignificant.

Performing a large retrospective of phyto- and zoo-indication, Măciucă (2003) proposed bio-monitoring as an important alternative to the traditional monitoring of forest ecosystems. Mohan & Gîrlea [31] established a clear correlation between the development of the reproductive organs of lichen species and environmental conditions, particularly the temperature and humidity which determine the number and size of apothecia.

Results and Discussion

The lichen flora of the Republic of Moldova and its ecobio-indication features

Aspects of the use of plants as bio-indicators have not so far been studied in Moldova. The undersigned initiated sporadic studies on lichens indication aspects in the Chițcani forest (1992), the Potoci forest resort (2001), and Chişinău (2001). In 2001, the laboratory of environmental impact and ecobio-indication was founded at the National Institute of Ecology, with research activities focused on lichen species as bio-indicators. A particular emphasis was put on bio-indicator features of lichens in forest and petricolous ecosystems. The Republic of Moldova Lichens Register was completed with 22 new species (Table 1).

Currently *c.* 200 species of lichens are known in Moldova, providing a substantial basis of biodiversity to be applied in the monitoring of environmental quality. Of importance for theoretical science is as well the placement of lichen species into a systematic classification [35]. The classification system used follows several works [49, 14] and scientific names are according to [25].

In terms of structure, the dominant species have a crustose thallus (108 spp.), but foliose species are also frequent (80 spp.). The last group is preferred in monitoring environmental quality. The proportion of fruticose lichens (18 spp.) is lower (Table 2).

Among environmental groups, established on the base of preferred substrate, the dominant group is corticolous epifleoid lichens (138 species), which inhabit wooded areas, growing particularly on tree trunks,. Among them are many bio-indicators of environmental quality, which can be successfully used in ecological monitoring of forests and other wooded areas. Rather large is the share of epilithic lichens (44 spp.), omnipresent in petricolous ecosystems, in the north and central part of the country, particularly in the basins of the Prut and Nistru Rivers. A small number of lichens grow directly on the surface of earth (epigeic lichens, 17 spp.), among which we reported a number of environmental quality indicators, particularly of steppe and agricultural ecosystems. The environmental group of epixilic lichens growing on wood parts of different constructions (7 species) also can complete the urban ecosystems bio-indicators register. Many of the lichen species analyzed can be attributed to more than one environmental group and can be used to monitor environmental quality in different types of ecosystems.

Table 1: Lichen species described for the first time in the Republic of Moldova and ecosystems where the species were identified during the period 2002-2005.

Name of species	Name of forest ecosystem
1. *Arthonia dispersa* (Schrad.) Nyl. (*A. epipasta* Körb. = *A. minutula* Nyl.)	Durleşti, Saharna, Cuhureştii de Sus
2. *Arthonia punctiformis* Ach. (*A. atomaria* Mass., *A. populina* Mass.)	Şoldăneşti, Burlăneşti
3. *Buellia lauri-cassiae* (Fee) Müll. Arg. (*B. triphragmia* Arn.)	Căpriana, Iabloana, Mândreşti
4. *Caloplaca aurantiaca* (Lightf.) Th. Fr. (*C. flavorubescens* (Huds.) J.R. Laundov /*Placodium aurantium* Vain.)	Plaiul Fagului
5. *Caloplaca elegans* Th. Fr.	Plaiul Fagului
6. *Candelaria concolor* (Dicks.) Stein.	Bălăneşti, Codri, Plaiul Fagului
7. *Leptogium saturninum* (Dicks.) Nyl.	Bahmut
8. *Hypocenomyce scalaris* Ach. ex. Lilj Choisy *(Psora scalaris)*	Plaiul Fagului
9. *Parmelia olivacea* (L.) Nyl. (*Imbricaria olivacea* DC. *Lichen olivaceus* Hoffm.)	Lopatna, Păpăuți, Căpriana, Iabloana, Lucăceni, Mândreşti, Şoldăneşti, Curchi, Cobac, Sărata Galbenă, Pogăneşti,
10.*Phaeophyscia nigricans* (Flk.) Stitzenb	Lopatna, Durleşti, Saharna, Cotul Morii Păpăuți, Şoldăneşti, Plaiul Fagului
11. *Physcia tribacia* (Ach.) Nyl.	Tețcani, Pererâta, Tohatin
12. *Physcia ciliata* (Hoffm.) Drietz (*Ph. obscura* Hampe)	Ciocana, Cărbuna, Congaz, Taraclia, Corneşti, Bahmut
13. *Parmeliopsis ambigua* (Wulf.) Nyl. (*Parmelia ambigua* Ach.)	Plaiul Fagului
14. *Verrucaria fuscella* (Turn.) Ach. (*V. areolata* Wallr.)	Lopatna (defileul Jiolnaia)
15. *Xanthoria substellaris* (Ach.) Vain (*X. fallax* Du Rietz = *X. ulophylla* Arn.)	Cuhureşti, Ciorna, «La Castel»
16. *Aspicilia gibbosa*	Lopatna
17. *Ramalina pulvinata* (Arnzi.) Nyl.	Iargara
18.*Parmelia pseudolivertorum*	Cobac, Sărata Galbenă
19. *Parmelia subaurifera*	Valea Mare
20. *Parmelia subulata*	Trebisăuți
21. *Evernia furfuracea* (L.) Mann. (*Parmelia furfuracea* (L.) Ach.)	Plaiul Fagului, Codri, Căpriana, Trebisăuți
22. *Microthelia atomaria* (DC) Korb.– *(M. korberi* Trevis.*)*	Plaiul Fagului, Rublenița, Temeleuți, Păpăuți

Studies on lichen chorology indicate the highest abundance of widespread (103 spp.) and common (73 spp.) species. Thus, the same bio-indicator species can be used to monitor environmental quality throughout the country and even in a regional or European context. Rare and very rare species make up 30 in all. Some may serve as bio-indicators for certain ecosystems, but their use as indicators at a wider level is not recommended. The study of rare and very rare lichens species should particularly focus on habitats where they can be conserved, and thus as a basis to identify suitable habitats for the creation of further state protected areas.

Table 2 Taxonomic spectrum of indicator lichens species in the Republic of Moldova

Indicator characteristics	**Number of species belonging to the *Orders***												
	***Caliciales* - 5**	***Lecanorales* - 126**	***Peltigerales* - 9**	***Teloschistales* -14**	***Pertusariales* - 7**	***Verrucariales* - 11**	***Graphidales* - 6**	***Arthoniales* - 8**	***Thricotheliales* - 2**	***Pyrenulales* - 2**	***Dothidiales* - 12**	***Ascomycota* - 4**	***Total* - 206**
Thallus structure:													
- crustose	5	48		6	7	9	6	8	2	2	11	4	108
- foliose	-	60	9	8		2					1		80
- fruticose	-	18											18
Ecological group:													
- epilithic	1	25		5		10	2	1					44
- epifleoid	3	85	3	9	7		4	7	2	2	12	4	138
- epigeic	-	11	6										17
- epixilic	1	5				1							7
Chorology:													
-very widespread	2	67	5	11	5		5	5			2	1	103
- common	3	49		3		4		3	1	1	6	3	73
- rare	-	10	4		2	7	1		1	1	4		30
Sensitive to pollution with:													
- SO_2		77	9	10	4	3	4	4			1	3	115
- NO_x		21	1	11								1	34
- O_3		3											3
- *Cl*		1											1
- *F*		3		1									4
Sensitive to:													
- *pH*		18	8									1	27
- *Ca*		23		6		9	1	1					40
- *Si*		4		2		3	1						10

Many species of lichens present in the Republic of Moldova can serve as indicators of environmental pollution, particularly air polluted by SO_2, NOx, O_3, Cl, F etc. Thus, sensitive to environmental pollution with SO_2 are 115 species: very sensitive - 20 species, sensitive -25, moderately sensitive - 50, resistant - 16 and very resistant to pollution - 4. Fairly receptive to pollution by Nox are 34 species, including resistant or indifferent (8 species). It is important to distinguish nitrophilous species to exclude them from impact assessment based on specific criteria of diversity and abundance per unit area, because they may have excellent development in NOx- rich environments, thus creating the impression of unpolluted air. For example, species of *Xanthoria* and *Physcia*, common and abundant on tree trunks along main roads, benefit from NOx pollution and emissions resulted from fuel combustion.

The number of lichen species sensitive to air pollution by fluorine (4), ozone (3) and chlorine (1) is small. Indicators of acidification are 27 species, of which 17 prefer an acid environment with a pH <5,4. Their presence in certain habitats or ecosystems may indicate the quality of the substrate or the degree of air pollution with acid ions. Epilithic species (44) inhabit limestone rocks (40 spp.) and partially silicate rocks (10 spp.). Among them, 7 species are rather sensitive to pollution (toxi-tolerance I–II) while 11 of them are listed as resistant (toxi-tolerance III–V). It is well known that epilithic species have a mainly crustose structure and such species are not recommended for ecobio-indication because they remain practically indifferent to pollutants at moderate and high concentrations [32]. Thus, monitoring of air quality in petricolous ecosystems based on lichens may not be feasible, except for habitats with trees where epifleoid species may serve as indicators.

The richness of species, as well as the morphological, ecological and chorological features of the lichen flora of the Republic of Moldova, allows for monitoring environmental factors within different types of ecosystem, especially forests and urban areas, less so in rocky, steppic, marsh and agricultural ecosystems.

Criteria for assessment of the environmental quality using lichen species

Toxitolerance

A large diversity of scales is applied to assess air quality on the base of lichen toxi-tolerance ranging from 3 to 12 steps, adding the level where lichens are lacking completely (‘desert zone’), those considered the most polluted area. Because from the biogeographical point of view, a desert still should have some vegetation (i.e. poor or rare), we propose that the level with the most pollutant-resistant lichens species should be considered ‘desert’ while the level where lichens are missing completely should be called ‘zero level’. We reviewed more than 20 scales currently applied in the monitoring of air quality in different climatic regions (boreal, temperate, subtropical). Trass [46] stated that using the list of indicator species one should take into consideration the fact that indicators are able to change their tolerance. He cited *Mycoblastus sanguinarius*, a species resistant to pollution in the Lake Baikal region (class IV) and very sensitive to pollution in the Baltic region (class I), the last being the western limit of its distribution. Among factors determining the degree of toxi-tolerance in the same species in different regions we can distinguish the spectrum of pollutants present in the air, their concentration and synergistic effects. Therefore, in order to ensure the correct estimation of the degree of toxi-tolerance of certain species it is recommended they be tested under laboratory conditions through exposure to gases or transplanting into the external environment.

By applying the a.m. method we established the presence of 40 lichen species as indicators of air quality: 3 species - with I degree, 16 species - II, 16 species - III, 3 species - IV, 2 species - degree V of toxi-tolerance, which may certainly form the basis of biological monitoring in our country. The frequency of these species in forest ecosystems is rather high, which guarantees the use of the same species for the forest sector, but also gives the opportunity to connect to the National and European Ecological Network, as many species are common to the European environment.

Gradations of the evaluation of air pollution with SO_2

Currently there is much information on disturbances to the vital activity of lichens caused by atmospheric pollutants [1, 16, 36, 44, 15, 29]. This has allowed some authors to specify gradations of SO_2 concentration [24, 26, 27]. The concentrations indicated vary greatly between authors, perhaps because some of the data were obtained in the laboratory, whereas others were obtained in field conditions; besides, such aspects as emission structure, climatic conditions, research methodology also differ. Most authors indicate a concentration of sulphur dioxide in the air of 0,05mg/m^3 as the threshold of the clean air zone. The harmful effects start occurring at 0,1–0,3mg/m^3, some indicating the concentrations > 0,3 mg/m^3 as very polluted air and the fatal concentration as being 0,5 mg/m^3. Basing on the analysis of literature, as well as field and laboratory testing of 15 lichen species, we propose a Toxi-tolerance Scale with 6 steps, as shown in Table 3.

Table 3: Gradations of SO_2 concentrations in the air and air quality expressed through lichens species toxitolerance

SO_2 concentration in the air (mg/m^3)	Air quality	Lichens toxitoleration	Toxitoleration degree
< 0,05	Not polluted	Highly sensitive	I
0,05 – 0,1	Slightly polluted	Sensitive	II
0,1 – 0,2	Moderately polluted	Moderately resistant	III
0,2 - 0,3	Considerably polluted	Highly resistant	IV
0,3 – 0,5	Heavily polluted	Desert zone	V
> 0,5	Critically polluted	Complete absence of lichens	VI

Gradations of Air Quality Evaluation

The presence of lichens as such is not necessarily an indication criterion, as previously stated for higher plants. To have an indicative value lichens must have a certain abundance. In our view, a coverage of 10% of the substrate surface could be a clear indicator. This threshold is very important, especially for toxi-tolerance grades I and II since we cannot state that the air is clean upon identifying a few plants of lichens very sensitive to pollution. For certain possible indicator species for the Republic of Moldova there were no information or the available information was controversial. Based on our research, which included results from laboratory and field observation on lichens from natural habitats, transplanted lichens and laboratory trials, new toxi-tolerance gradations were established or their initial toxi-tolerance modified. Proceeding from the abundance and toxi-tolerance of the indicators we have elaborated a scale with gradations for the evaluation of air quality (Table 4).

Table 4: Gradations in air quality assessment based on abundance of lichens with different toxitolerance

Air quality	SO_2 content in the air (mg/m^3)	Abundance of species with different toxitoleration degree, % of substrate surface	Conventional color
1. Clean	<0,05	I > 10 or I < 10 and II > 75	blue
2. Slightly polluted	0,05-0,1	I – 0 -10 or II – 50-75	green
3. Moderately polluted	0,1-0,2	II - 10-50 or III > 50	violet
4. Polluted	0,2-0,3	III - 10-50 or IV > 50	yellow
5. Heavily polluted	0,3-0,5	IV - 10-50 or V - 1-100	red
6. Critically polluted	>0,5	Complete absence of lichens	brown

Application of lichen indication in air quality monitoring

The evaluation of air quality by applying the lichen indication method to 62 forest ecosystems throughout the Republic of Moldova (Fig. 1), allowed us to identify 90 lichen species, of which 50 are bio-indicators.

Based on this method, four forest ecosystems were evaluated as having clean air (Ocnița-Hădărăuți, Bahmut, Selişte-Leu, and Potoci); the number of ecosystems with slightly polluted air reaches 11, moderately polluted - 31, polluted - 13, heavily polluted - 3 (Criva, Saharna, Copanca), while those with critical pollution level are absent (Table 5). The air quality from the ecosystems reported as clean is confirmed by the presence of lichen species very sensitive to pollution, the coverage of which was over 10% of substrate surface (i.e. *Usnea hirta* in Ocnița-Hădărăuți, *Peltigera canina* in Bahmut, and *Ramalina fraxinea* in Selişte-Leu).

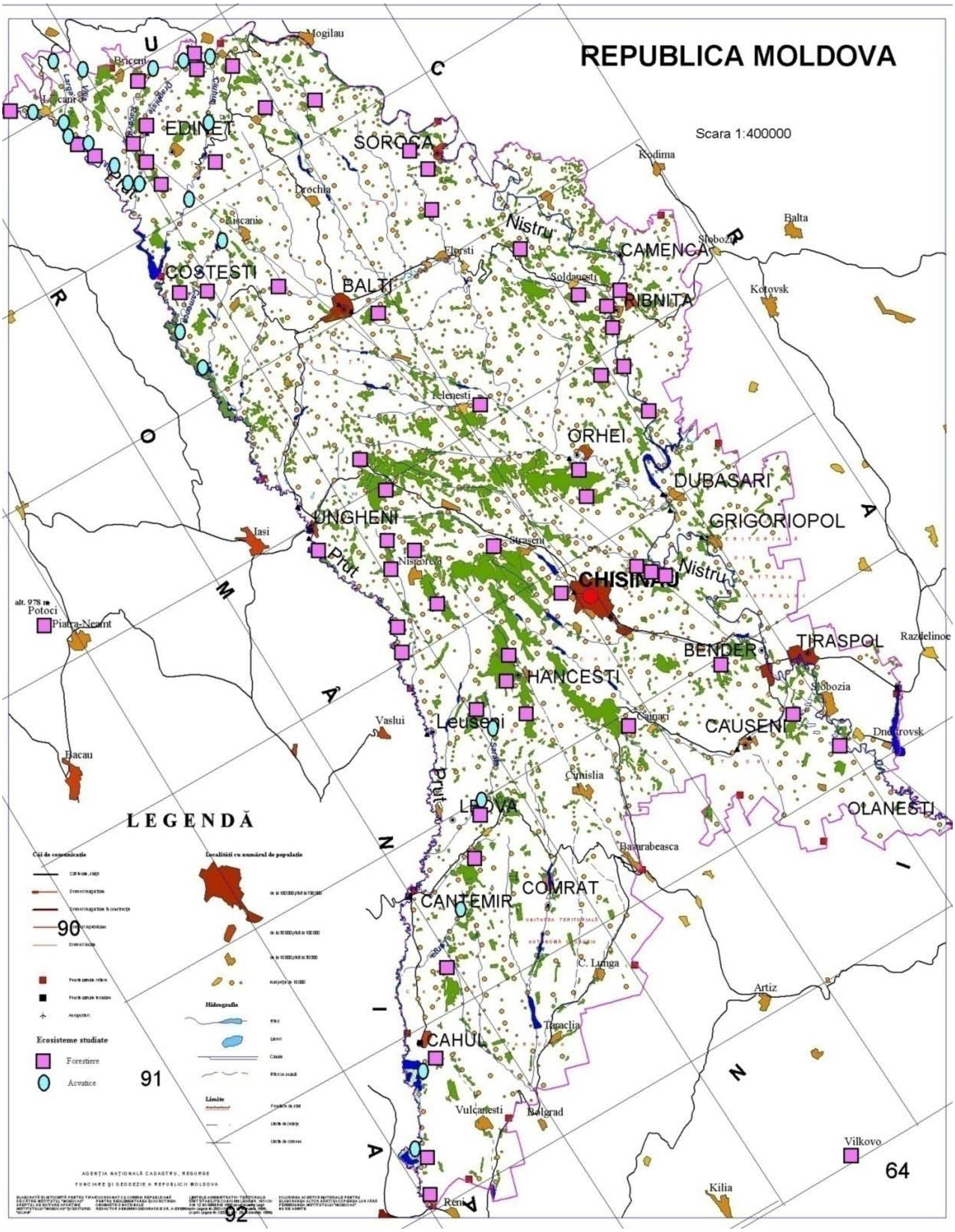

Fig. 1: Evaluated forest ecosystems

Ecosystems with slightly polluted air (SO_2 = 0,05–0,1 mg/m^3 air) are primarily located in the north of the country (Trebisăuți, Feteşti, La Castel, Zăbriceni, Lipnic, Donduşeni) and some of them in the central part (Bujor, Cimişeni, Logăneşti) and in the middle part of the basins of the Dniester (Lopatna) and Prut Rivers (Cotul Morii).

Ecosystems with moderately polluted air (SO_2 = 0,1– 0,2 mg/m^3 air) are more numerous (31) and have a wide distribution throughout the country, often being subject to impact from local pollution sources (Hâjdieni, Criva, Orhei, Selişte, Durleşti, Budeşti, Văleni, Giurgiuleşti, etc.) or from trans-boundary sources, particularly areas on hillsides of western aspect (e.g. Bălăneşti, Cobac). The number of ecosystems with polluted air (SO_2 = 0,2–0,3 mg/m^3 air) is 13, prevailing in the vicinity of cities and sources of industrial pollution (e.g. Trinca, Chetroşica Nouă, Mândreştii Noi, Păpăuti, Şoldăneşti, Tohatin, Hârbovăț, Ciobruciu). Heavily polluted air (SO_2 = 0,3–0,5 mg/m^3 air) was established for three ecosystems – Criva, Saharna, and Copanca, located in the immediate vicinity of pollution sources and in the path of the prevailing winds. Ecosystems with critical polluted air (SO_2 > 0,5 mg/m^3 air) were not recorded. More pronounced air pollution by SO_2 is specific for ecosystems located around obvious sources of pollution. Here the bio-indicators of toxi-tolerance degree II and III do not exceed 5% of the substrate coverage (sometimes over 10% in case of nitrophilous species – Văleni, Giurgiuleşti, Criva region); species of toxi-tolerance degree III, IV or V, most being nitrophilous species, are persistent. In addition, ecosystems with polluted air are poor in diversity (often only 4 – 6 species).

Typically, the ecosystems with slightly polluted air are located at altitudes above 200 m and those with polluted air below 200 m, but there are many exceptions, because the distance from the pollution source and the direction of prevailing winds are also important factors (for example sites at Trinca, Călărăseuca, Chetroşica Nouă, Mândreştii Noi, Saharna are situated at altitudes above 200 m but are still rather polluted). Compared with the Potoci site (mountain type), most forest ecosystems in the Republic of Moldova are of the hilly type (200-600 m) or level (0-200m). Rather enhanced can be considered the effects of pollution in ecosystems located on plain areas for instance those around Valea Mare, Nemțeni, Crihana Veche, Vilcovo (Ukraine), and for Criva, Hâjdieni, Orhei, Tohatin, Copanca, Hârbovăț, Cioburciu the determining role was played by the distance from the pollution source of and the direction of prevailing winds.

Most SO_2 emissions from local sources are concentrated in the south-east of the country with a major source in the Tighina-Tiraspol-Cuciurgan area. This led to pollution of ecosystems located in the south-east due to prevailing NW–SE winds, which we confirmed through bio-indication. The emissions of SO_2 from the Soroca and Bălți sources led to the degradation of the Hâjdieni ecosystem. The mineral exploration of Criva and Trinca, the latter also being affected by unauthorized burning in the lime production process, have placed these ecosystems in the category of highly polluted air. High emissions of SO_2 (332 tonnes/year), are characteristic for the town of Hânceşti, their remnants impacting on the state of the air of adjacent ecosystems, Sărata Galbenă and Sărata-Mereşeni, which correspond to air pollution values caused by SO_2 (IPA=25–50). Chişinău's emissions have evidently contributed to the pollution of the ecosystems of Balmaz - Hârbovăț in the south-east and Tohatin-Budeşti towards the east. The effects of pollution from the Rezina - Râbnița source were reported only in the immediate vicinity (Saharna, Ciorna, Păpăuți), due to the direction of winds from NW to SE, leaving unaffected the ecosystems Pohribeni and Lopatna. The possible harmful effects, catastrophic for vegetation, from the Cuciurgan source were more pronounced in Copanca and less in Cioburciu-Răscăieți, again due to the direction of winds from the NW to SE. The south part of the country is affected by trans-boundary pollution (Galați in România), especially Crihana Veche, as well as Giugiuleşti and Văleni. The effects of pollution from the sources located in Iaşi, inseparable from those of Ungheni, strengthen the pollution of ecosystems in the region around – Valea Mare, Nemțeni, less Bălănesti, Cobac, but fortunately not reaching Bahmut and Corneşti located in the NE from the pollution sources and as a result are protected by the high relief of the Codri forest reservation.

Table 5: The estimation of air quality in forest ecosystems according to Air Quality Gradations Scale (AQGS – Begu, 2008) and the Air Purity Index (API - DeSloover, 1968, with our adjustments)

Ecosystems	**Criva**	**Pererîta**	**Teţcani**	**Trebisăuţi**	**Trinca**	**Feteşti**	**La Castel**	**Zăbriceni**	**Clocuţna**	**Ocniţa - Hădărăuţi**	**Lipnic**	**Cernoleuca**	**Donduşani**	**Climăuţi**	**Călărăşauca Moşana**	**Chetroşica**
API (*DeSloover*,1968)	**21**	**62**	**49**	**66**	**13**	**43**	**104**	**85**	**82**	**154**	**63**	**50**	**70**	**31**	**8**	**30**
AQGS(*Begu*)	**V**	**III**	**III**	**II**	**IV**	**II**	**II**	**II**	**III**	**I**	**II**	**III**	**II**	**III**	**IV**	**IV**
Altitude, m	**140**	**120**	**150**	**270**	**230**	**260**	**260**	**250**	**260**	**280**	**280**	**265**	**280**	**265**	**275**	**255**
Exposition	**SV**	**N**	**NV**	**SV**	**V**	**NE**	**V**	**N**	**SE**	**SE**	**NE**	**SW**	**NW**	**SW**	**NE**	**NE**
Pollution hotbed	**Edineţ – Lipcani**								**Edineţ – Mogilău**							

Ecosistems	**Rubleniţa**	**Rădulenii Vechi**	**Stânca Mare**	**Hăjdieni**	**Iabloana**	**Măndreştii Noi**	**Ciorna**	**Păpăuţi**	**Şoldăneşti**	**Cuhureştii de Sus**	**Saharna**	**Pohribeni**	**Lopatna**	**Orhei**	**Selişte**	**Ivancea**
API	**23**	**48**	**14**	**13**	**70**	**36**	**72**	**26**	**32**	**49**	**8**	**65**	**131**	**29**	**39**	**38**
AQGS	**III**	**III**	**III**	**III**	**III**	**IV**	**III**	**IV**	**IV**	**IV**	**V**	**III**	**II**	**III**	**III**	**III**
Altitude, m	**310**	**350**	**220**	**140**	**230**	**250**	**190**	**260**	**320**	**310**	**210**	**260**	**210**	**180**	**261**	**200**
Exposition	**NE**	**E**	**W**	**NW**	**S**	**NE**	**SW**	**E**	**E**	**NE**	**SW**	**E**	**E**	**N**	**NE**	**N**
Pollution hotbed	**Soroca-Iampol-Bălţi**						**Rezina – Râbniţa – Orhei**									

Ecosystem	**Cimişeni**	**Logăneşti**	**Sărata-Mereşeni**	**Sărata-Galbenă**	**Hîrbovţăul-Nou -Balmaz**	**Copanca**	**Cioburciu – Răscăieţi**	**Cărbuna**	**Vilcovo**	**Sărata-Nou ă**	**Codr. Tigheci**	**Crihana-Veche**	**Văleni**	**Giurgiuleşti**	**Congaz**	**Taraclia**
API	**76**	**97**	**37**	**44**	**21**	**15**	**49**	**79**	**32**	**20**	**58**	**10**	**19**	**12**	**41**	**26**
AQGS	**II**	**II**	**III**	**III**	**IV**	**V**	**IV**	**III**	**IV**	**III**	**III**	**V**	**III**	**III**	**III**	**III**
Altitude, m	**190**	**310**	**320**	**250**	**160**	**150**	**170**	**200**	**2**	**220**	**300**	**180**	**150**	**60**	**170**	**160**
Expos.	**W**	**E**	**SW**	**W**	**SE**	**NW**	**NE**	**NW**	**-**	**NE**	**SW**	**SW**	**SE**	**S**	**NW**	**NW**
Pollut.hotbed	**Chişinău**						**Tighina – Tiraspol – Cuciurgan**					**Tiraspol – Cuciurgan-Cahul**				

Ecosystem	**Potoci**	**Valea Mare**	**Nemţeni**	**Cotul Morii**	**Corneşti**	**Bahmut**	**Bălăneşti**	**Selişte-Leu**	**Cobac**	**Bujor**	**Căpriana**	**Durleşti**	**Tohatin**	**Budeşti**
API	**159**	**24**	**15**	**92**	**67**	**102**	**60**	**64**	**53**	**40**	**45**	**88**	**9**	**68**
AQGS	**I**	**IV**	**IV**	**II**	**III**	**I**	**III**	**I**	**III**	**II**	**III**	**III**	**IV**	**III**
Altitude,m	**978**	**90**	**80**	**80**	**380**	**340**	**429**	**380**	**380**	**240**	**320**	**220**	**200**	**200**
Expos.	**W**	**-**	**-**	**-**	**W**	**NE**	**NW**	**SE**	**NE**	**SE**	**NE**	**NW**	**N**	**NW**
Pollut. hotbed	**Ungheni – Iaşi**							**Chişinău-Hânceşti**						

According to the EMEP Report 1/2003 issued by the Meteorology Institute, Norway, trans-boundary pollution is manifested in many countries in Europe. Moldova is located in the area of annual SO_2 deposition equal to 700–1000 kg/km^2. The comparison between the results of lichen indication applied to 62 ecosystems, to the EMEP results (Table 6), shows that the EMEP network (50x50 km grid) is hindering the real environmental state, probably because pollution effects are more pronounced within 25–30 km from the pollution source. For example, in the 86/64 sectors the 11 ecosystems studied showed the air to be clean (e.g. Ocnița), slightly polluted (Feteşti, Trebisăuți, Zăbriceni ecosystems), moderately polluted (Clocuşna and Cernoleuca) or polluted (Trinca and Chetroşica Nouă). At the same time, the EMEP matrix characterizes the state of the air as polluted.

Table 6: Air quality of researched forest ecosystems, according to EMEP 50x50km (large rectangles) comparing to our evaluations (based on small squares)
Ecosystems EMEP networking distribution (32dials 50x50km grid)

North – South Direction	**West – East Direction**						
	62	**63**	**64**	**65**	**66**	**Total**	**Ro, Ua**
85	**Ro**	**1**	**-**	**Ua**	**Ua**	**1**	
86	**Ro**	**2**	**11**	**1**	**Ua**	**14**	
87	**Ro**	**2**	**1**	**2**	**-**	**5**	
88	**Ro**		**2**	**1**	**4**	**7**	**1- Ro**
89	**Ro**	**3**	**6**	**4**	**1**	**14**	
90	**Ro**	**1**	**4**	**3**	**-**	**8**	
91		**2**	**1**	**3**	**-**	**6**	
92	**3**	**2**	**-**	**-**	**-**	**5**	
93	**-**	**Ua**	**Ua**	**Ua**	**Ua**	**-**	
94	**Ua**	**Ua**	**1- Ua**	**Ua**	**Ua**	**-**	**1- Ua**
Total	**3**	**13**	**25**	**14**	**5**	**60**	**2**

Note: Ro - Romania Ua - Ukraine
low polluted air moderate polluted air
polluted air highly polluted

The 50x50 km grid is likely to be indicative in large forest areas and/or plain landscape (for instance Belarus, the Baltic states, Poland, Russia, etc.) but is less meaningful for the Republic of Moldova, a country with low forest coverage and fragmented landscape, which can re-direction the pollution effects. Thus, at the national level it is recommended the application of 25x25 km grid.

Conclusions

1. The Republic of Moldova Lichens Register has been established, based on a literature review and our own research, which includes *c*. 200 species and varieties (22 noted by the author).

2. The basis of lichens as ecobio-indicators has been established, based on the presence of 40 indicator species sensitive to air pollution by SO_2, NOx etc.

3. Two criteria for the evaluation of the state of environmental components have been proposed: a Lichen Toxi-tolerance Scale (LTS) with 6 levels, taking into account the degree of air pollution by SO_2, the similarity of geographical conditions, and the results of own testing

through applying gases, transplanting and studies in the field; and Gradations for Air Quality Assessment (GAQA) in forest and urban ecosystems, based on indicator abundance/coverage, toxi-tolerance and correlation between different bio-indicator species.

4. Results obtained from the biological monitoring of 62 forest ecosystems has allowed us to argue the potential and efficiency of the lichen indication method in air quality monitoring.

BIBLIOGRAPHY

1. Atlas, R. M., Schofield, E., 1975, Respons of the lichens Peltigera aphthosa and Cetraria nivalis and alga Nostoc commune to suplur dioxide, natural gas and crude oil in Artic Alaska, *Astarte V.*, **8** (2): 35-38.
2. Bartók, K., 1980, Influenţa poluării atmosferice asupra florei lichenologice din zona industrială a Zlatnei, *Contrib. Bot.*, **20**: 195-199.
3. Bartók, K., 1985, Cartarea poluării atmosferice pe baza sensibilităţii lichenilor, *Contrib. Bot.*,**25**: 51-57.
4. Bartók, K., Rusu, A.-M., Kozma, A., 2003, Caracterizarea gradului de poluare al oraşului Cluj-Napoca prin componentul lichenologic, *Environment and Progress*, Cluj-Napoca: 29-33.
5. Begu, A., 2004, Evaluarea impactului asupra ecosistemelor silvice prin metoda bioindicaţiei, *Buletinul AŞM, Ştiinţe biologice, chimice şi agricole,* **1**, 292: 156-161.
6. Begu, A., 2005, Ecobioindicaţia – metodă eficientă în monitorizarea calităţii mediului, *Mediul Ambiant, Revistă ştiinţifică de informaţie şi cultură ecologică. Ediţie specială. Chişinău*: 45-49.
7. Begu, A., 2006, Air pollution monitoring in forest ecosystems using bioindicators, *7th Subregional Meeting on Effect-oriented Activities in the Countries of Eastern and South-eastern Europe*, Baia Mare, România, 28 septembrie – 1 octombrie: 65-78.
8. Begu, A., 2008, Aplicarea scalelor bazate pe toxitoleranţa lichenilor în reflectarea calităţii aerului, *Contrib. ştiinţ. în tehnol. şi echipam. pentru eval. şi protecţia mediului*, Simpoz. Naţ. cu particip. internaţională. Ed. a IV-a. 26-28 septembrie. Arcalia (Bistriţa-Năsăud, România): 24-25.
9. Begu, A., Boguş, S., 2001, Unele particularităţi ecologice în răspândirea lichenilor din preajma staţiunii Potoci (jud. Neamţ*), Simp. Jub. cons. aniv. 30 ani a rezerv. „Codrii”,*Vol. I, Lozova: 5-6.
10. Begu, A., Călugăreanu, N., Buburuz, D., 2003, Aspecte privind elaborarea standardelor ecologice pentru evaluarea ecosistemelor, *Buletinul AŞM, Ştiinţe biol., chim. şi agric.,* **2,** 291: 134-138.
11. Begu, A., Liogchii, N., Creţu, A., 2006, Aspecte privind lichenoflora unor ecosisteme forestiere şi calitatea aerului. *Conferinţa internaţională „Aspecte ştiinţifico-practice a dezvoltării durabile a sectorului forestier din Republica Moldova”*, Chişinău 17-18 noiembrie, ICAS: 150 – 155.
12. Begu, A., Manic, Şt., Şalaru, V., Simonov, Gh., 2005, *Ciuperci. Plante fără flori*. Min. Ecologiei şi Resurselor Naturale al Rep. Moldova. Acad. de Şt. a Rep. Moldova. Fondul Ecologic Naţ. – Ch.: Î.E.P. Ştiinţa, (Combinatul Poligr.) – Ser.: „Lumea vegetală a Moldovei”, **I**: 204.
13. Begu, A., Simonov, Gh., 2006, Biodiversitatea lichenofitelor evidenţiate în perioada 2001-2005 în ecosistemele naturale ale Republicii Moldova, *Materialele Simpozionului Jubiliar - Rezervaţia „Codrii”-35 ani*, Lozova: 26-27.
14. Bisby, F.A.,Rugierro, M.A., Wilson, K.L., Cachuela-Palacio, M., Kimani, S.W., Roskov, Y.R., Soulier-Perkins, A., van Hertum, J., 2005, *Species 2000 & ITIS Catalogue of life: 2005 Annual Checklist.* CD-ROM; Species 2000: Reading, U.K.
15. Blium, O.B., 1986, Sravnitelinaia oţenca deistvia toxiceskih gazov na CO_2 – gazoobmen lişainicov, *Ecologicesk. i fiziologo-biohim. aspectî antropotoler. rastenii*. Vses. Conf. Tezisî dokl., **I**, Tallin: 39-41.
16. Burton, M.A.S., 1986, Biological monitoring of environmental contaminants (plants), *Monitoring and Assessment Research Centre, King's College London, University of London, MARC Report,* Number 32.
17. Colun, A., 2001, Lichenoflora rezervaţiilor peisagistice „Saharna” şi „Ţipova” şi a rezervaţiei „Prutul de Jos*”, Rezumatele lucrărilor. Simpozion Jubiliar consacrat aniversării a 30 ani de la formarea rezervaţiei „Codrii”*, Vol I, Lozova: 14-15.
18. Cretzoiu, P., 1941, *Flora lichenilor folioşi şi fruticuloşi epidendri şi epixili din România*, ICEF, Bucureşti, **47**: 1-72.
19. Crişan, F., 2002, Aprecierea comparativă a calităţii mediului în două aglomerări urbane: Bruxelles şi Cluj - Napoca, utilizînd ca bioindicatori macrolicheni epifiţi, *Mediul - cercetare, protecţie şi gestiune. Univ. Babeş – Bolyai, Cluj – Napoca*: 34-35.
20. Crişan, F., Pop, I., 1997, Epiphyte foliose lichens–bioindicators of air pollution in the city of Cluj-Napoca, *Beitrage zur Naturwissenschaftlichen Erforschung Seibenbiirgens*, Bohlau Verlag Koln: 135-143.
21. Cristea, V., Baciu, C., Gafta, D., (eds.), 2002, *Municipiul Cluj-Napoca şi zona periurbană: studii ambientale*, Ed. Accent, Cluj-Napoca: 332.

22. Garrou, E., Castrogiovanni, G., 1991, *Indicatori biologici.-Piemonte parchi*, Numero 42. AnnoVI. № 7, ottobre. Spedizione in Abbonamento Postale Gr. IV/70%. II° simestre: 30-32.
23. Guderian, R., 1979, *Zagreaznenie vozduşnoi sredî*, Perevod s angliiscogo N. S. Geliman. Izd-vo Mir, Moskva: 200.
24. Hawksworth, D. L., Rose, F., 1970, Quantitative scale for estimating sulphur dioxide air pollution in England and Wales using epiphytic lichens, *Nature*, **227**:145-148.
25. Kondratyuk, S., Khodosovtsev, A., Zelenko, S., 1998, *The second checklist of lichen forming, lichenicolousand allied fungi of Ukraine*, Kiev, Phytosociocentre: 180.
26. Le Blanc, F., Rao, D., 1972, Effects of sulphur dioxide on lichen and moss transplants, *Ecology*, **54** (3): 612-617.
27. Liiv, S., Martin, L., Piarn, H., Ăănsaar, A., 1982, Sravnenie rezultatov fitoindicații i drugih metodov, ispolizovannîh dlia opredelenia zagriaznennia vozduha v gorodah Ăstonii, *Problemî sovremennoi ăcologii, Ăcologiceskie aspectî ohranî ocrujaiuşcei sredî v Ăstonii*, Tezisî II respubl. Ăcolog. Conf., Tartu: 50.
28. Măciucă, A., 2003, Aspecte privind utilizarea bioindicatoilor în supravegherea ecosistemelor, *Bucovina Forestier*, **XI** (1): 53-58.
29. Mihailova, I. N., Vorobeicik, E. L., 1995, Ăpifitnîe liheno-sinuzii v usloviah himicescogo zagreaznenia: zavisimosti doza-ăfect, *Ăcologia,* **6**: 455-460.
30. Mîrza, M., Obuh, P., 2004, Lichenoflora din Rezervația „Pădurea Domnească", *Buletin științific al Muzeului Național de Etnografie și Istorie Naturală*, vol. 1(14), Chişinău: 227-236.
31. Mohan, Gh., Gîrlea, D., 1980, Lichenii şi briofitele - indicatori ai gradului de poluare atmosferică, *Studii şi comunicări*, Muzeul Piteşti, **V**: 21-24.
32. Nilison, Ă. M., 1986, Ăcologiceskie osnovî antropotolerantnosti ăpifitnîh lişainicov, *Ecologicesk i fiziologo-biohim. aspectî antropotoler, Rastenii*, Vses. Conf., Tezisî dokl., **I**, Tallin: 126-127.
33. Nylander, W., 1865, Les lichens du Jardin de Luxemburg, *Bul. bot.*, France, **V** (13): 364-372.
34. Obuh, P., Colun, A., 2001, Diversitatea lichenilor crustacei din zonele protejate ale Prutului mediu, *Biodiversitatea vegetală a Republicii Moldova.* Culegere de articole științifice, Chişănău, Centrul Editorial al USM: 149-153.
35. Reivn, P., Ăvert, R., Aikhorn, S., 1990, *Sovremennaia botanica*, ***I; II***, Moskva, Iz-vo Mir: 348; 344.
36. Richardson, D. H. C., Nieboer, E., 1980, Surface binding and accumulation of metals in lichens, Cellular interactions in symbiosis and parasitism, *Columbus: Ohio State University Press*: 75- 94.
37. Simonov, Gh., 2004, Lichenofitele din spațiul teritorial al Republicii Moldova, *Grădina Botanică la 50 de ani / Cartea Moldovei*, Tipografia Universul: 78-81.
38. Simonov, Gh., Istrati, A., Chirtoacă, V., 1994, Contribuții floristice în landşaftul natural „Trebujeni", *Congresul I al botaniştilor din Moldova*: 14-15.
39. Simonson, S., 2003, *Lichens and Lichen - Feeding Moths (Arctiidae: Lithosiinal) as Bioindicators of Air Pollution in the Rocky Mountain Front Range*.
40. Ştefănescu, G., Micluța, A., Bartók, K., 1992, Zonarea intensității poluării atmosferice în bazinul industrial Baia Mare cu ajutorul lichenilor, *Buletin științific, Seria B.* **IX,** Fascicola: Fizică - Chimie, Biologie., Univ. din Baia Mare: 199-205.
41. Ştefănescu, G., Bartók, K., 1998, Criterii lichenologice în cartarea intensității poluării atmosferice în centre urbane şi bazine industrial, *Buletin științific, Seria B,* **XIII**, Chimie - Biologie., Univ. de Nord Baia Mare: 127-132.
42. Ştefănescu, G., Bartók, K., 1998, Noi date privind cartarea lichenologică a intensității poluării atmosferice din bazinul industrial Baia Mare, *Buletin științific, Seria B.*, **XIII**, Chimie – Biologie, Univ. de Nord Baia Mare: 133-137.
43. Trass, H., 1968, *Analiz lihenoflorî Ăstonii*, Avtoref. dis. d-ra nauk. Tartu: 80.
44. Trass, H., 1977, Lişainiki i zagreznenosti vozduha, *Jizni rastenii, **3**, Vodorosli. Lişainiki*, Pod red. Prof. M.M. Golerbaha, M., Prosveşcenie: 431-433.
45. Trass, H., 1982, Lihenoindikația kak metod biomonitoringa dinamiki okrujaiuşcei sredî, *Problemî sovremennoi ăcologii, Ăcologiceskie aspectî ohranî ocrujaiuşcei sredî v Ăstonii*, Tezisî II respubl, Ăcolog. Conf., Tartu: 47-48.
46. Trass, H., 1984, Classî poleotolerantnosti lişainicov i ăcologiceskii monitoring, *Problemî ăcologiceskogo monitoringa i modelirovania ăcosistem.*, L.: Gidrometeoizdat: 144-159.
47. Vasilenko, S., 2005, Ăcologiceskie osobennosti lişainicov Mereneştskogo lesa, *Ecologie şi Protecția Mediului – cercetare, implementare, management*, Mater. Conf. Jubiliare – INECO 15 ani. 29 dec. 2005. Ch.:Institutul Național de Ecologie: 95-98.
48. Vrabie, Gr., 1934, Materiale pentru studiul lichenilor din regiunea Chişinăului, *Buletinul Muzeului Național de Istorie Naturală din Chişinău*, Redactat de Dr. I. Lepşi, **5**, 1933, Chişinău, Tipografia „Tiparul Moldovenesc": 88-121.
49. ****, Global Biodiversity. Earth's resourse in the 21st century*, 2000: 246.

50. ***, *Republica Moldova. Primul Raport Național cu privire la diversitatea biologică*, 2000, Chişinău: 65.

CONTRIBUȚII LA STUDIUL LICHENOFLOREI REPUBLICII MOLDOVA ŞI APLICAȚIILE SALE ÎN MONITORINGUL CALITĂȚII AERULUI ATMOSFERIC

(Rezumat)

În anul 2001 în cadrul Institutului Național de Ecologie (INECO) a fost fondat laboratorul Impact ecologic şi ecobioindicație, tematica cercetărilor fiind orientată spre lichenoindicație. Ulterior, autorul împreună cu dr. Gh. Simonov (anii 2002 – 2005), plasează accentul cercetărilor pe particularitățile ecobioindicatoare ale speciilor de licheni din ecosistemele forestiere şi pietrofite, completând registrul lichenoflorei RM cu încă 22 specii. Actualmente lichenoflora țării înregistrează circa 200 de specii şi varietăți. Sistemul de clasificare utilizat de noi este cel aplicat de Kondratyuk et al. (1998).

Lichenoflora Republicii Moldova este bine reprezentată de specii de indicatori veritabili ai poluării mediului, îndeosebi a aerului atmosferic cu diferiți poluanți chimici – SO_2, NOx, O_3, Cl, F etc. Astfel, sensibile la poluarea mediului cu SO_2 sunt 115 specii, dintre care foarte sensibile – 20, sensibile -25, moderat sensibile – 50, rezistente – 16 şi foarte rezistente la poluare - 4 specii. Sunt recomandate 40 specii de licheni, care au o răspândire largă în ecosistemele forestiere ale Republicii Moldova, ca indicatori veritabili ai gradului de poluare a aerului cu SO_2. Au fost elaborate şi propuse spre aplicare 2 criterii de evaluare a mediului: 1 – Scala Toxitoleranței Lichenilor (STL) cu 6 trepte, tinând cont de gradul de poluare a aerului cu SO_2, similitudinea condițiilor geografice şi rezultatele testărilor proprii prin expunerea la emisii gazoase, transplantare şi studiu în teren; 2 - Gradații de Evaluare a Calității Aerului (GECA) în ecosistemele forestiere şi urbane, bazate pe abundența/acoperirea reală a substratului de către indicator, gradul de toxitoleranță şi co-raportul dintre diferite specii ecobioindicatoare.

Rezultatele obținute în cadrul monitoringului biologic din 62 ecosisteme forestiere ne-au permis să argumentăm teoretic posibilitatea şi eficacitatea utilizării lichenilor ca biomonitori ai calității aerului atmosferic. Racordarea lichenoindicației, stabilită pentru cele 62 ecosisteme studiate, la rețeaua EMEP 50x50 km, conform cvadratelor în care e cuprinsă RM, denotă o camuflare a situației ecologice reale, probabil datorită faptului că efectele poluării locale sunt mai pronunțate până la circa 25–30 km de la sursa de poluare. Grila EMEP 50x50 km, probabil e recomandată în cazul zonelor extinse de păduri (taiga) şi relief de câmpie (Belarusi, Țările Baltice, Polonia, Rusia etc.) şi nicidecum pentru suprafețele de pădure izolate şi puține din RM, amplasate prioritar pe relief accidentat, care redirecționază esențial efectele poluanților nocivi, atât locali, cât şi transfrontalieri. Astfel, la nivel național este necesar a aplica grila de 25x25 km.

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