Lagascalia 19(1-2): 505-512 (1997)

AIR QUALITY MONITORING, USING EPIPHYTIC LICHENS, IN SOME NORTHERN-ITALIAN AREAS (LOMBARDY AND PIEDMONT)

ANDREA ZOCCHI, PARIZIA CASARINI, PIETRO GENONI, LUIGI GUIDETTI, VALERIA ROELLA, CRISTINA BORLANDELLI & MARIA VITTORIA STEFANETTI

Abstract

This study is based on biomonitoring of air pollution using epiphytic lichens in some Northern Italian and Southern Switzerland areas. Lichens were used as bioindicators (I.A.P.) and bioaccumulators of heavy metals in a limited area. Maps show the results of the inquiry: colours are related to different air qualities.

Introduction: survey area and aim of the study

This study reports the monitoring of air quality in some areas placed in northern Italy and southern Switzerland (Fig. 1) by means of epiphytic lichens as biomonitors (DERUELLE, 1978; HAWKSWORTH & al.,1970; NIMIS & al., 1990).

The study was carried out in an area of 6.500 km^2 including the town of Varese (54,93 km^2) and the eastern side of Ticino Valley Park (906 km^2), in a more detailed way.

Lichens were also utilised as bioaccumulators of heavy metals (BARGAGLI, 1989; NIMIS & al., 1992) in the zone of Cusio, neighbouring Lake Orta, in the administrative province of Novara. This is a tourist area (594 km^2), where mechanical and chemical industrial enterprises, such as foundries, galvanic industries, metal cleaning and pressing, cocks and similar goods manufacturing, are present.

The survey was completed within three years (from 1991 to 1994) with the exception of the Swiss area, where the research is still in course. A total of 1277 relevés on Tilia sp. and *Quercus* sp. was carried out over 425 stations.

The aim of this study is to integrate biological data with physic and chemical ones generated by recording instruments, in order to point out the "risk areas" and program aimed interventions and reclamation planes.

Methods

In this study the following methods were used:

1, The *Calibrated Lichen Index of Air Quality* (I.A.P. - Index of Air Purity), proposed by LIEBENDOERFER & al. (1988) and modified by NIMIS & al. (1991). This index is based on the frequency of epiphytic lichen species within a sampling grid of

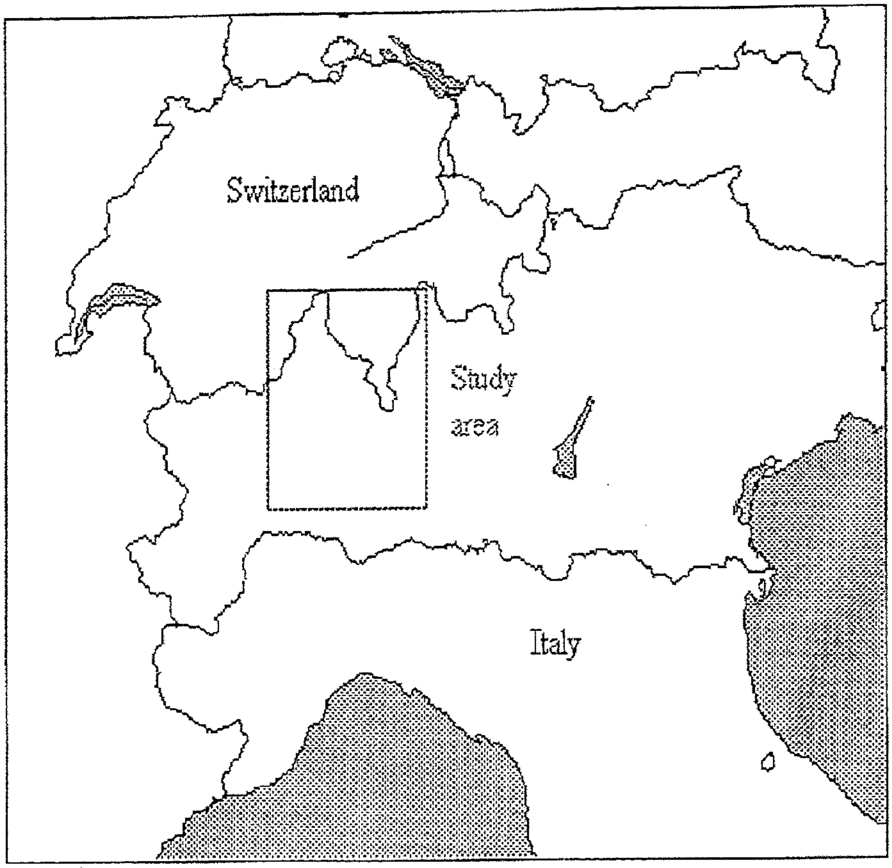

Fig. 1. Study area.

10 units. It reveals a high degree of correlation with pollution by SO_2 and other phytopoisonous gases.

2, The analysis of heavy metals in lichen thalli (NIMIS & al., 1992): the concentrations of 16 heavy metals in standard dry samples of *Parmelia caperata* collected in 36 stations were determined by graphite furnace atomic absorption spectrometry for As, Cd, Cr, Ni, Pb, Se, V and by plasma atomic emission spectroscopy for Al, Ba, B, Fe, Mn, Pd, Cu, Ti, Zn.

3, The *Wirth's Ecological Indices* (WIRTH, 1980) with the aim to evaluate the influence of some microecological factors on distribution of lichens.

Results and conclusions

The I.A.P. values have been elaborated with the program package SURFER (Golden Software, Inc.). They allowed to draw a pollution map of the territory, subdividing it into 7 zones, characterised by different air qualities, indicated by different colours.

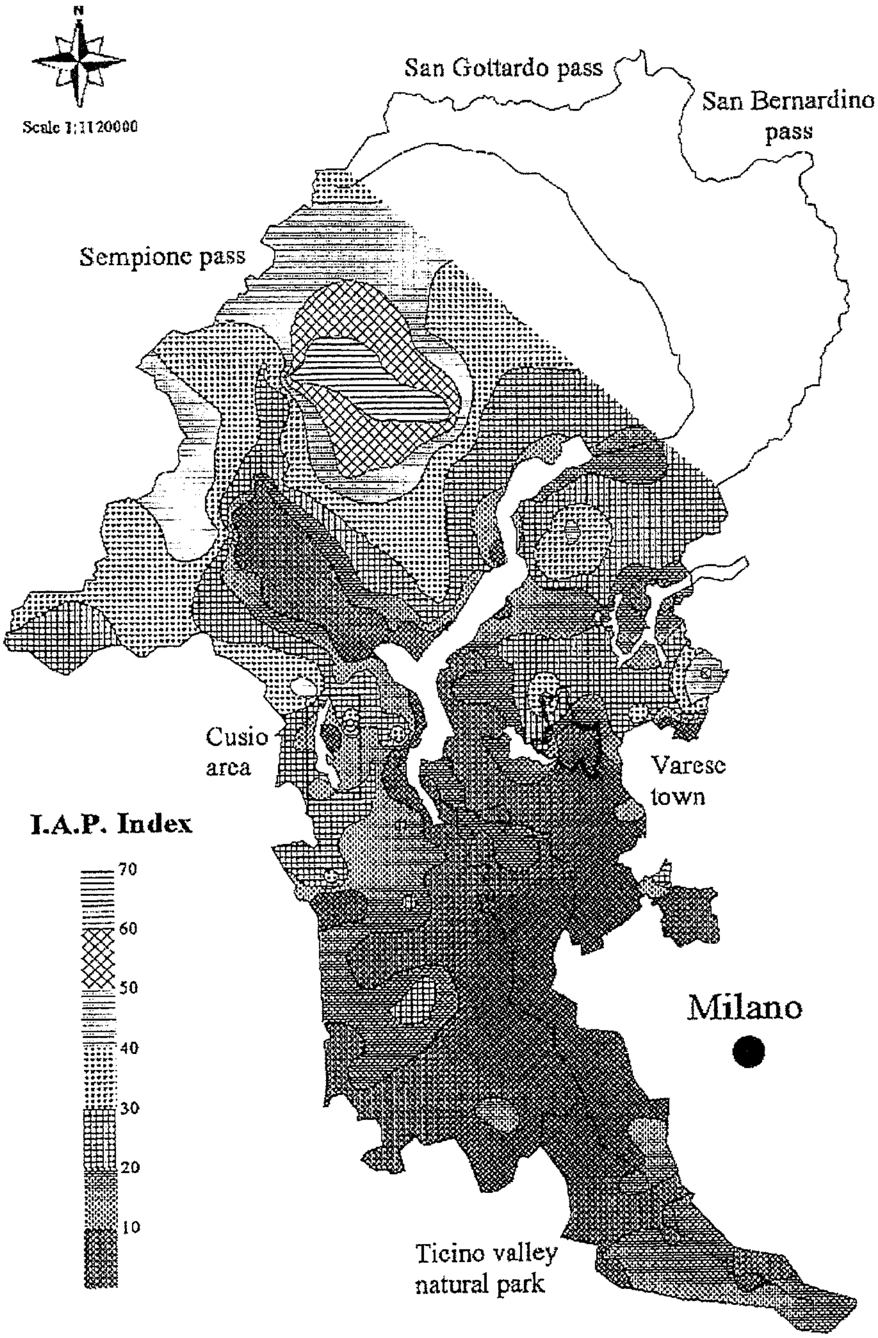

Fig. 2. General air quality map. Administrative provinces of Varese and Novara (Italy), Canton Ticino (Switzerland).

The I.A.P. map of the whole area is shown in Fig. 2, the map of the town of Varese in Fig. 3 and the one representing the Lombard Ticino Valley Natural Park in Fig. 4.

Over a wide area, I.A.P. values lower than 10 coincide with the highest population density, the location of many industrial activities and intense vehicle traffic.

Departing from these zones and increasing the altitude there is an increase in lichen presence: the highest values have been recorded in the mountainous areas, far from the towns.

On the general map the grey and red zones, indicating a bad air quality, correspond to the 53.4% of the study area, the orange and yellow zones, indicating an average air quality, correspond to the 34.8 % and the green and blue zones, indicating a good air quality, are the 11.8 % of the investigated territory

These results have been confirmed by a significant correlation between I.A.P., SO_2 and NOx concentrations measured by recording devices situated in the study area.

The concentration of the these phytopoisonuos gases is mainly due both to petrol compounds burning in loco and, probably, to the main wind transport from extremely industrialised and overpopulated neighbouring zones.

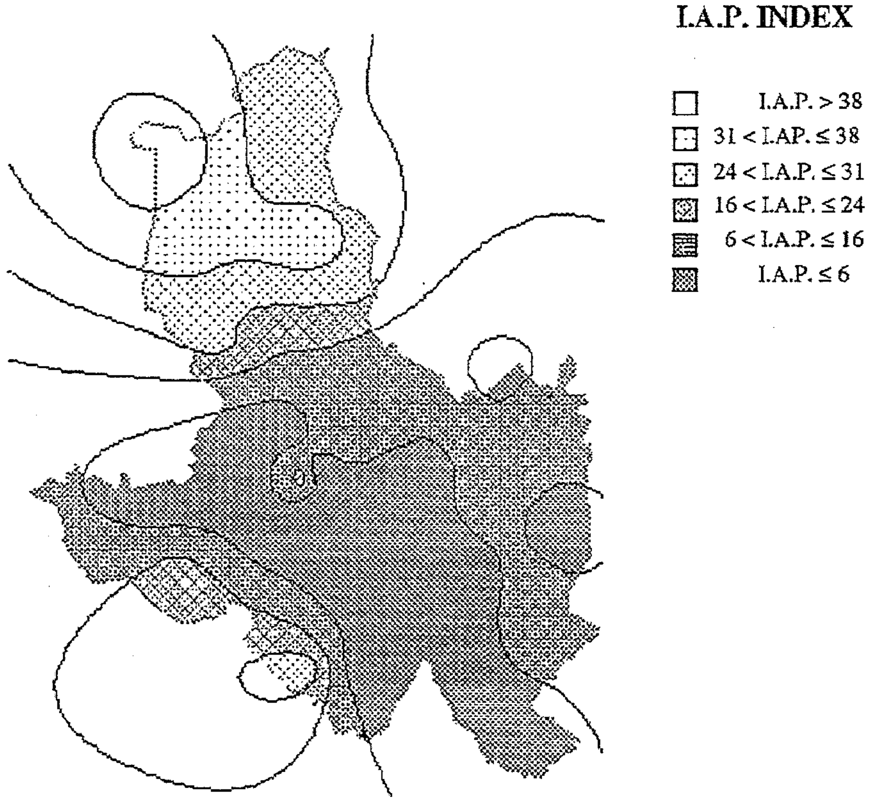

Fig. 3. Air quality map - Varese town.

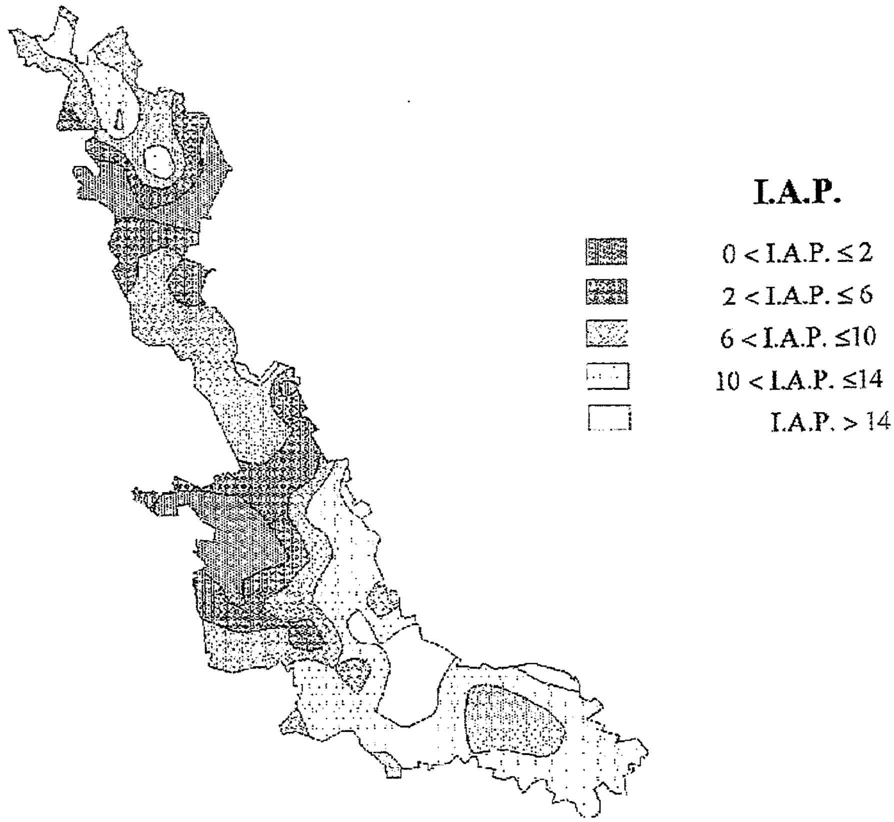

Fig. 4. Air quality map: Ticino river valley natural park.

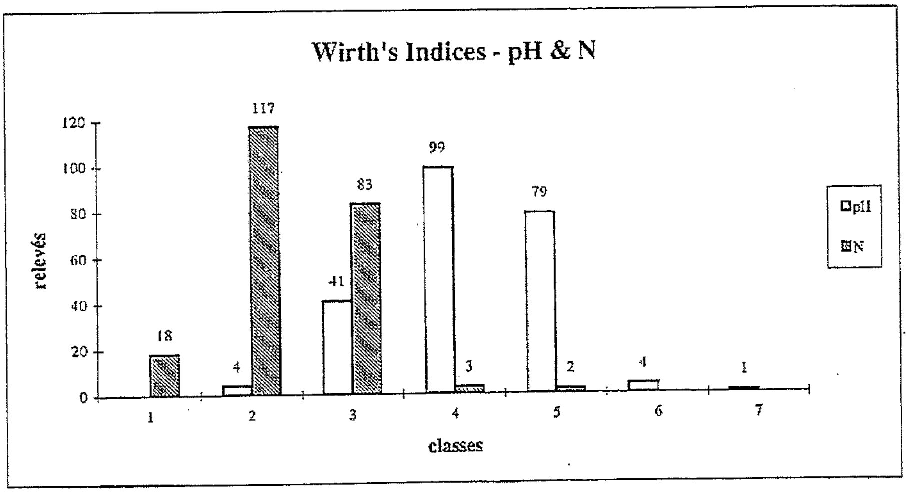

Fig. 5. Wirth's Index.

1) Amandinea punctata	27) Lecania cyrtella	52) Parmelia glabratula	77) Physcia adscendens
2) Arthonia radiata	28) Lecanora allophana	53) Parmelia pastillifera	78) Physcia aipolia
3) Arthonia punctiformis	29) Lecanora intumescens	54) Parmelia quercina	79) Physcia biziana
4) Caloplaca cerina	30) Lecanora carpinea	55) Parmelia revoluta	80) Physcia clementei
5) Caloplaca ferruginea	31) Lecanora chlarotera	56) Parmelia saxatilis	81) Physcia dubia
6) Caloplaca holocarpa	32) Lecanora conizaeoides	57) Parmelia sinuosa	82) Physcia semipinnata
7) Candelaria concolor	33) Lecanora hagenii	58) Parmelia subaurifera	83) Physcia stellaris
8) Candelariella reflexa	34) Lecanora pulicaris	59) Parmelia subrudecta	84) Physcia tenella
9) Candelariella xanthostigma	35) Lecanora quercicola	60) Parmelia sulcata	85) Physcia vitii
10) Cetraria pinastri	36) Lecanora subfuscata	61) Parmelia tiliacea	86) Physconia detersa
11) Cladonia caespiticia	37) Lecanora symmicta	62) Parmeliopsis ambigua	87) Physconia distorta
12) Cladonia coniocraea	38) Lecidea sp.	63) Parmotrema chinense	88) Physconia grisea
13) Cladonia deformis	39) Lecidella elaeochroma	64) Pertusaria albescens	89) Physconia perisidiosa
14) Cladonia fimbriata	40) Lecidella euphorea	65) Pertusaria amara	90) Physconia venusta
15) Cladonia parasitica	41) Lepraria sp.	66) Pertusaria flavicans	91) Pseudoevernia furfuracea
16) Cladonia squamosa	42) Leprocaulon microscopicum	67) Pertusaria pertusa	92) Ramalina fastigiata
17) Cladonia strepsilis	43) Normandina pulchella	68) Pertusaria pseudocorallina	93) Rinodina exigua
18) Collema subflaccidum	44) Opegrapha atra	69) Phaeophyscia cloantha	94) Rinodina pyrina
19) Evernia divaricata	45) Opegrapha varia	70) Phaeophyscia endophenicea	95) Scoliciosporum chlorococcum
20) Evernia prunastri	46) Parmelia acetabulum	71) Phaeophyscia hirsuta	96) Umbilicaria deusta
21) Graphis scripta	47) Parmelia caperata	72) Phaeophyscia hispidula	97) Usnea sp.
22) Hypogymnia adglutinata	48) Parmelia elegantula	73) Phaeophyscia insignis	98) Xanthoria fallax
23) Hypogymnia bitteriana	49) Parmelia exasperata	74) Phaeophyscia orbicularis	99) Xanthoria parietina
24) Hypogymnia physodes	50) Parmelia exasperatula	75) Phaeophyscia poelti	
25) Hypogymnia tubulosa	51) Parmelia glabra	76) Phlyctis argena	
26) Hypogymnia vittata			

Table 1. Lichen Species found. Names according to "*The lichens of Italy*" by NIMIS (1993).

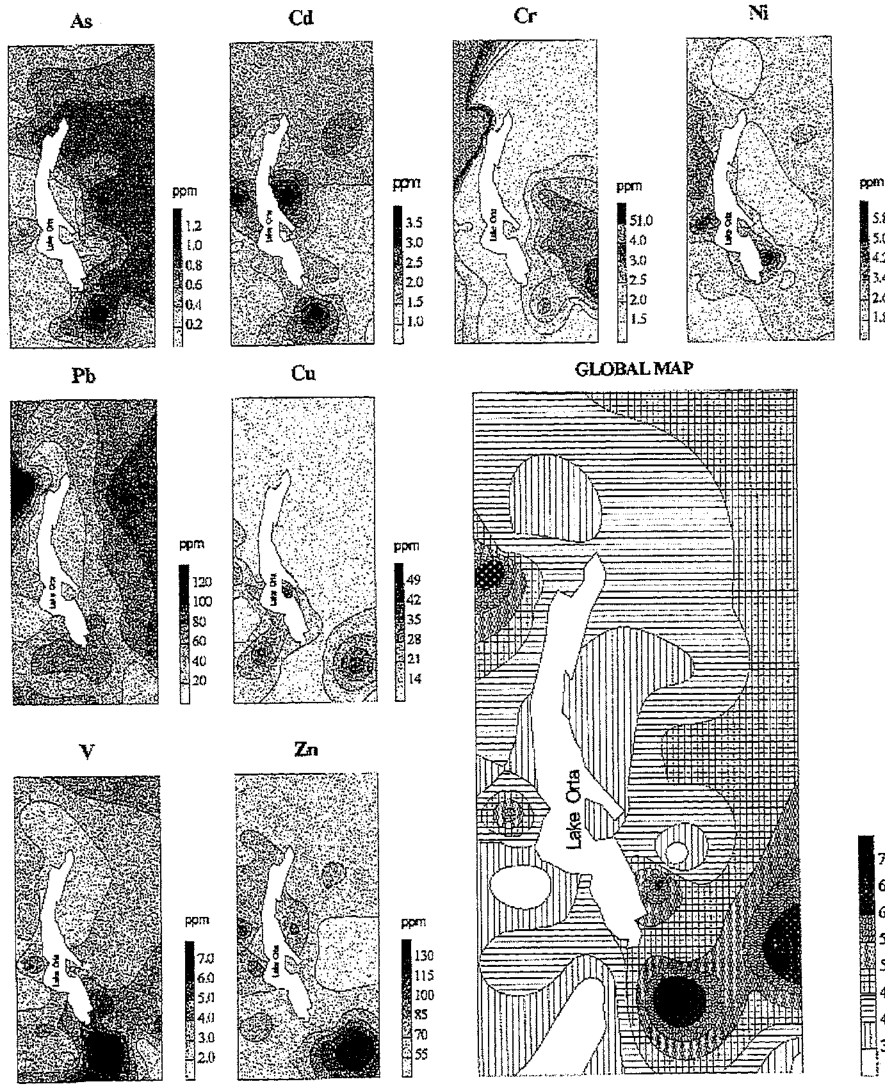

Fig. 6. Heavy metals concentration in lichen thalli - Cusio Area.

Lichenic species found in the survey area (OZENDA & al., 1970), designated by NIMIS (1993), are carried on Table 1.

Data obtained by means of floristic relevés have been elaborated according to Wirth's Ecological Indices, concerning the influence of some environmental factors, for example the substratum acidity and nitrogenous compounds deposition.

Fig. 5, visualises these indices distribution, expressed by numerical values. These bar graphs show the main ecological states in the survey area. The pH driving forces are a compromise among secondary substrate eutrophization (increasing pH), acid rains and tree steam essudates. In general, most of the pH values found are higher (Wirth's pH class 5) than those expected from literature. This could be due to a prevailing N enriched dust depositions coming from industrial activities or road traffic.

Notwithstanding this, nitrogenous depositions are not so high to influence the lichen communities composition in respect of nitrogenous needs; as a matter of fact most of the stations shows a moderate nitrophytism (Wirthís N class 2).

Fig. 6 illustrates the contamination maps of As, Cd, Cr, Ni, Pb, Cu, V, Zn and the global quality map of Cusio's area, showing the total contamination of all the metals.

In the global map the data relative to each metal have been normalised using the highest value and then summed: the survey area has been subdivided into 9 "quality" classes. Over the 80% of the biomonitored territory (about 475 km^2 in the N - NE direction) is included in the 4 best classes (normalised values ranging from 3,5 to 5). Only the 4% (about 24 km^2 in the S - SW direction) is included in the worst classes, with values ranging from 6 to 7.

The southern area, with the greatest number of polluting emissions (industrial agglomerations and towns), appears to be the most compromised by depositions of Cd, Cr, Pb, Cu, Zn.

References

BARGAGLI, R. (1989) Determination of metal deposition pattern by epiphytic lichens. *J. Toxicol. Environ. Chem.*, **18**: 249-256.

DERUELLE, S. (1978) Etude comparÈe de la sensibilitÈ de trois methodes díestimation de la pollution atmospherique. *Rev. Bryol. Lichenol.*, **4**, **44**: 429-441.

HAWKSWORTH, D. L. & L. ROSE (1970) - Qualitative scale for estimating sulfur dioxide air pollution in England and Wales using epiphytic lichens. *Nature* **227**: 145-148.

LIEBENDOERFER, L., R. HERZIG, M. URECH & K. AMMANN (1988) Evaluation und Kalibrierung der Schweizer Flechten-Indikationsmethode mit wichtigen Luftschadstoffen. *Staub-Reinhaltung der Luft* **48**: 233-238.

NIMIS, P. L. (1993) *The lichens of Italy: an annotated catalogue.* Mus. Reg. Scie. Nat., Torino. Monografia XII.

—, M. CASTELLO & PEROTTI, M. (1990) Lichens as biomonitors of sulphur dioxide pollution in La Spezia (Northern Italy). *Lichenologist* **22** (3): 333-344.

—, A. LAZZARIN & G. & D. GASPARO (1991) *Lichens as bioindicators of air pollution by SO2 in the Veneto region (NE Italy).* Co. Ge. V. s.r.l., Verona, Ecothema s.r.l., Trieste.

—, M. CASTELLO & M. PEROTTI (1992) *Lichens as bioindicators of Heavy Metal Pollution: a case study at La Spezia (N Italy).* VCH Publishers. pp. 265-284.

OZENDA, P. & G. CLAUZADE (1970) Les lichens. Etude biologique et flore illustrÈe. Masson, Paris.

WIRTH, V. (1980) Flechtenflora. Eugen Ulmer. Stuttgart.

Addresses of the authors:

Dr. A. Zocchi, Istituto Cantonale Batteriosierologico, Via Ospedale 6, 6904 Lugano, Switzerland; Dr. P. Casarini, Azienda USSL 42, P.M.I.P., U.O. Fisica e Tutela Ambiente, via N. Bixio 13, 27100 Pavia, Italy; Dr. P. Genoni, Azienda Sanitaria USSL 34, P.M.I.P., U.O. Fisica e Tutela Ambiente, via Spagliardi 19, 20015 Parabiago, Milano, Italy; Dr. L. Guideti & Dr. M. V. Stefanetti, Azienda Regionale USSL 13, L.S.P., Sez. Biotossicologica, via Roma 7/D, 28100 Novana, Italy; Dr. V. Roella & Dr. C. Borlandelli, Azienda Sanitaria USSL 1, P.M.I.P., U.O. Fisica e Tutela Ambientale, via Caretti, 5, 21100 Varese, Italy.