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MONITORING OF AIR POLLUTANTS BY EXPOSED LICHENS IN SALZBURG (AUSTRIA)

Monitoring von Luftverunreinigungen mit Hilfe von Flechtenexponaten in Salzburg (Austria)

by

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Key words: Lichens, air pollution, transplant experiments.
Schlagwörter: Flechten, Luftverunreinigung, Exposition.

Summary: Between March and September 1995 specimens of *Hypogymnia physodes* were exposed at 9 different sites in the area of Salzburg and Hallein according to the method of WERNER (1993) in order to evaluate the effects of air pollutans. The sites coincided with the official stations of pollution monitoring run by the provincial government of Salzburg. As a vitality criterion the CO_2-gas exchange was measured in a time interval of two weeks. Visible damage and the growth of the exposed lichen samples were determined photographically. The change of vitality parameteres showed significant dependencies on deposition of air pollutants and on climatic factors.

Zusammenfassung: Zwischen März und September 1995 wurden Proben von *Hypogymnia physodes* an 9 verschiedenen Standorten in Bereich Salzburg und Hallein nach der Methode von WERNER (1993) exponiert, um die Wirkungen von Luftverunreinigungen zu verfolgen. Die Expositionsorte stimmten mit den offiziellen Luftmeßstationen des Amtes der Salzburger Landesregierung überein. Als das Vitalitätskriterium wurde der CO_2-Gasstoffwechsel alle zwei Wochen bestimmt. Sichtbare Schädigungen und das Wachstum wurden photographisch dokumentiert. Die Veränderungen der Vitalitätsparameter zeigten signifikante Abhängigkeiten von der Deposition von Luftverunreinigungen und von klimatischen Faktoren.

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Introduction

Lichens reflect the pressure on the environment caused by harmful substances due to their complex reactions on a variety of air pollutants. The knowledge on the average pollution of the atmosphere is ultimately important for the public health.

The method of transplantation of lichens is successfully used since BRODO (1961) and SCHÖNBECK (1969). As citeria for the assessment of the effects of air pollutants visible changes of the lichen thalli (e.g. SCHÖNBECK 1969) can be used as well as physiological parameters such as the CO_2-gas exchange (e.g. SCHUMM & KREEB 1979; CHRIST & TÜRK 1982) or a combination of both procedures (WERNER 1993).

The object of the presented work is to investigate the influence of different air pollutants (SO_2, NO, NO_2, O_3 and dust) as well as of the climatic factors on the CO_2-gas exchange of exposed lichens in order to assess the air quality in areas with a general low air pollution.

Materials and Methods

Between March and September 1995 specimens of *Hypogymnia physodes* (L.) NYL. were exposed to ambient air at 9 different sites in the area of Salzburg and Hallein in order to record the effects of several air pollutants on physiological parameters of lichens. The sites coincided with environmental air monitoring sites of the provincial government of Salzburg.

Number:	Site (Abbr.)	Altitude:	Monitoring system:
		m.s.m.	
1	Rudolfsplatz (Ru.)	425	SALIS
2	Bot. Garten - Freisaal (Fr.)	430	TEMPIS
3	Lehen - Hochhaus (Le.)	455	SALIS
4	Itzling (It.)	425	SALIS
5	Zistelalm - Gaisberg (Zi.)	1010	SALIS/TEMPIS
6	Flughafen - Maxglan (Fl.)	430	TEMPIS
7	Hallein - Hagerkreuzung (Ha.)	440	SALIS
8	Hallein - Winterstall (Wi.)	650	SALIS/TEMPIS
9	St. Koloman - Kleinhorn (Ko.)	1005	Umweltbundesamt

Table 1: The 9 sites of exposition of the lichen samples in and around Salzburg (SALIS=Salzburger Luftgüte Informations System; TEMPIS=Temperatur Informations System).

The lichen samples were fixed on discs of cork and placed on sprucewood slabs, according to WERNER (1993). The lichens were collected near Lauda (Taubertal, Germany) and St. Koloman (Taugltal, Salzburg, Austria).

For the determination of the vitality only optically faultless lichen thalli of approximately the same size were used.

The gas exchange measurements were carried out with a compact-CO_2/ H_2O-Porometer (CPQ 130, Walz GmbH, Effeltrich) and an BINOS 100 4P (Rosemount Analytical) with a gas cooler unit (MGK 1) immediately before the exposing of the lichens and afterwards every fortnight. The apparent photosynthesis (AP) was determined at a photon flux density of 1000 $\mu mol.m^{-2}.s^{-1}$ and a temperature of 20 - 21° C. The gross photosynthesis (GP), which cannot be measured directly, is equivalent to the sum of net photosynthesis and dark respiration. The quotient of gross photosynthesis and dark respiration results in the economic coefficient of photosynthesis ($EC = GP.DR^{-1}$).

The visible thallus damage (VDT, in percentage of the thallus area) and the relative thallus area (RTA) were determined monthly. The photographs of the exposed lichens were scanned into a personal computer by a digital camera (Sony) and measured out precisely in order to determine the area of the damaged lichen thalli or the growth of the exposed lichen thalli.

The results of the vitality of the lichens were correlated to climatic and air pollution data by means of regression analyses. The parameters of vitality (AP; EC, VDT, RTA) were divided into nine degrees of injury (table 2 and 3) and combined into a physiological vitality index (PVI; table 4) where the 4 vitality parameters were combined into 11 physiological vitality indices (PVIs).

degrees of injury	AP [mg CO_2 gdw^{-1} h^{-1}]	EC [GP DR^{-1}]
0	> 2.50	> 3.95
1	2.35 - 2.50	3.80 - 3.95
2	2.25 - 2.35	3.60 - 3.80
3	2.15 - 2.25	3.50 - 3.60
4	2.05 - 2.15	3.30 - 3.50
5	1.90 - 2.05	3.05 - 3.30
6	1.80 - 1.90	2.85 - 3.05
7	1.60 - 1.80	2.65 - 2.85
8	< 1.60	< 2.65

Table 2: Classification of the parameters 'apparent photosynthesis' (AP) and 'economic coeffizient' (EC) into degrees of injury.

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	RTA [%]	VDT [%]
0	> 112.0	3 100
1	108.0 - 112.0	99.94 - 99.99
2	106.0 - 108.0	99.90 - 99.94
3	104.0 - 106.0	99.80 - 99.90
4	103.5 - 104.0	99.60 - 99.80
5	102.0 - 103.5	99.40 - 99.60
6	100.5 - 102.0	98.50 - 99.40
7	100.0 - 100.5	93.00 - 98.50
8	< 99.99	< 93.0

Table 3: Classification of the parameters 'relative thallus area' (RTA) and 'visilbe thallus damage' (VDT) into degrees of injury.

	AP	EC	RTA	VDT
PVI 1	x	x	x	x
PVI 2	x	x	x	
PVI 3	x	x		x
PVI 4	x		x	x
PVI 5		x	x	x
PVI 6	x	x		
PVI 7	x		x	
PVI 8	x			x
PVI 9		x	x	
PVI 10		x		x
PVI 11			x	x

Table 4: Possible combinations of the single parameters to different physiological vitality indices (PVI).

Results

The pressure on the area examined caused by the registrated components SO_2, NO, NO_2 and O_3 was low during the summer period 1995. Thus the visible thallus damage showed only small differences between the various sites. Only at the sites 7 to 9 (figure 1) a decrease of undamaged thallus area was detectable at the beginning of June 1995.

At almost all sites a growth of the exposed thalli was observed. The lichens exposed at site 2; 4 and 5 showed the most intensive growth. The area of the thalli increased up to 16%. Individual lichens of the sites 7; 8 and 9 grew after a phase of shrinking again, while at the same exposition tables several

individuals grew and other ones showed reduction of their thallus area.

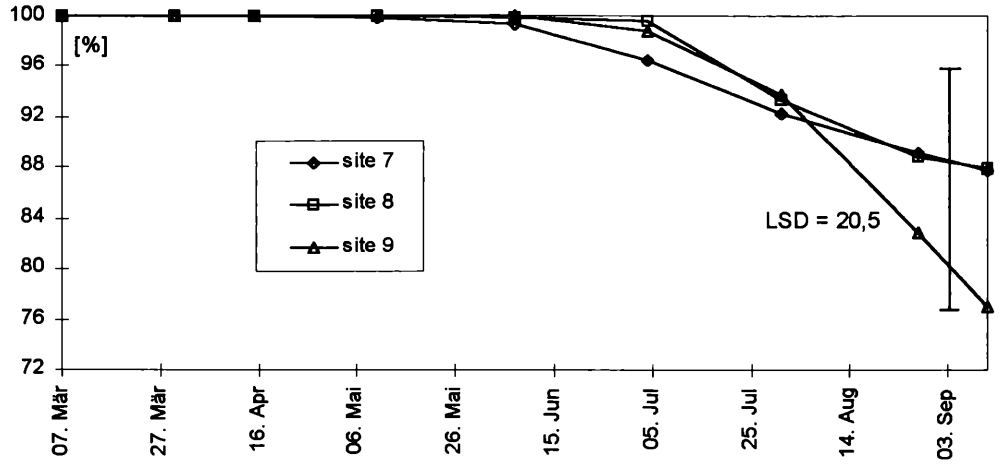


Figure 1: Decrease of the undamaged thallus area at the sites 7 to 9 (LSD: least significant difference value).

The net photosynthesis changed during the exposition time only slightly. The most significant reduction of the net photosynthesis was found at sites 7 and 8. Two specimens showed here merely no apparent photosynthesis at the end of the exposition any more. The economic coefficent of photosynthesis shows a significant variation among the various sites. At the sites 1; 7; 8 and 9 a trend torwards reduction of the coefficent value was detected, while at sites 4 and 5 an increase was found. At site 3 it remained constant and at site 2 the coefficient decreased slightly.

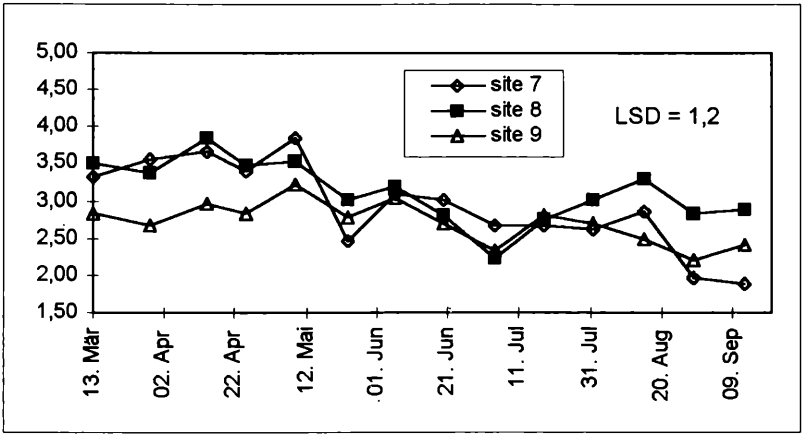


Figure 2: The economic coefficient of the photosynthesis at the sites 7; 8 and 9 (n=6).

The vitality parameter RTA exhibit a significant relation to the climatic data. There is also a determination coefficient of 17% to the deposition data and about 25 % to the ozone concentration.

For the parameter AP significant correlations were found for the dust pollution, relative air humidity and the climatic data. The economic coefficient of the photosynthesis proved to be a reliable parameter, which showed significant correlations to all climatic data (except precipitation) just as to some deposition data, as well as for the dust pollution, ozone concentration and the combinded deposition factors.

The 3 PVIs combined from the parameters VDT & RTA (= PVI 11), VDT & RTA & AP (= PVI 4) and VDT & RTA & EC (= PVI 5) correlated best with climatic and deposition data (table 5). Therefore these three parameters were used in a final analysis for the assessment of the biological effects of air quality and they demonstrated zones of different air pollution levels.

	climate		**deposition**		**environment**[1]	
factor	R^2	a	R^2	a	R^2	a
PVI 1	.663	.000	.172	.029	.833	.000
PVI 2	.536	.000	.169	.026	.724	.005
PVI 3	.498	.000	.132	.098	.758	.002
PVI 4	.699	.000	.241	.004	.883	.000
PVI 5	.732	.000	.221	.007	.868	.000
PVI 6	.351	.000	.181	.020	.557	.062
PVI 7	.509	.000	.158	.037	.798	.001
PVI 8	.483	.000	.132	.078	.840	.000
PVI 9	.612	.000	.181	.019	.771	.001
PVI 10	.521	.000	.163	.039	.832	.000
PVI 11	.778	.000	.321	.000	.879	.000

Table 5: By means of multiple regression analysis determined correspondence between the different physiological vitality indices (PVI 1 - PVI 11) and the environment parameters of the respective sites. Specified is the determination coefficient R^2, which describes the degree of correspondence and the error probability a.

[1] ... combination of climatic and deposition data.

The results showed that of the 9 test sites, 3 fell into each of the categories of low (site 2; 4 and 5), medium (site 1; 3 and 6) and relatively high air pollution (site 7; 8 and 9).

Discussion

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The present investigation demonstrates that the method developed by WERNER (1993) is a simple and fast means to estimate the effetcs of air pollution. By means of PVIs (see table 4) it is possible to determine air quality more accurately than by the method of VDT alone.

The results clearly showed that only a combination of the several vitality parameters allow a precice description of the actual air quality situation: As a rule those lichens, which exhibited only very sligth visible damage of the thalli, also showed the most intensive growth of the thallus area.

On the other hand several lichens grew in spite of the increase of bleached areas. An example for this fact can be found at site 7, where the value of the relative thallus area was 3, while those of the visible thallus damage was 7.

Therefore the results would have been much less differentiated if the air quality situation would have been estimated only by means of the visual thallus damage as intended by the VDI guidline 3799.

If only this method were used, the sites 7; 8 and 9 would have been classified as relatively high polluted too, but site 1 would have been allocated to the category of low pollution.

This example shows clearly that the application of the VDI guidline 3799 (VEREIN DEUTSCHER INGENIEURE 1991) on its own doesn't lead to definite results in areas with relatively low air pollution.

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