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LICHENS AS POTENTIAL INDICATORS OF ENVIRONMENTAL HARM

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ABSTRACT

Environmental protection is one of the most important issues of our time; thereby there is an increasing awareness to regulate activities that degrade the environment pollution. Physical and chemical instrumentations provide accurate quantitative data to the various substances that are polluting but do not give a true picture of the extent of contamination that has impact on living organisms. The environmental impact on organisms and its effects on habitat can be detected by bioindicator plants. We chose Cladonia lichen as a biological indicator. We measured the photosynthetic activity of the algae cells and applied chlorophyll fluorescence induction method for the detection of environmental impacts. The most harmful toxic elements are Cd, Cr, Cu, Ni, Zn, Pb and toxic gases are NO_2, SO_2. We measured the accumulation of toxic elements in Cladonia lichen populations.

Today, the pollution of our environment is mostly caused by cars. A significant amount of Pb in the air comes from the exhaust gases of motor vehicles and contaminant are deposited along the roads. The measurement results confirm that lead contamination have been multiplied by six in the Buda crossing due to the heavy traffic. Transplanted lichen colonies show that the Cd contamination is more than thirty-fold at busy roads than in the National Park. The Cr value also increased by more than double, so it can be stated that mostly roads are blamed for the raise of the level of such toxic elements.

Keywords: Cladonia lichen biological indicator, toxic gases, toxic elements

INTRODUCTION

For a long time certain lichen species were considered suitable to use as indicator species of ecological continuity. Such indicator species are difficult to conquer new habitats. Therefore, it is important for them to have a continued existence, and corresponding micro-climatic factors of the habitats, usually huge old trees are also essential. The slowly decaying, very hard wood or deep bark grooves are essential to their survival. In addition there is secondary importance of having a closed canopy or prevailing humid environment inside the rain forests. Plasmatic resistance, ecological water demand, the relative air humidity and contamination play role in the indications. The toxic effect of sulphur dioxide on lichen depends on the pH of the soil. The lichens live in different substrates. Mainly epiphytic lichens are taken into account as biological indicators. Sulphur dioxide destroys unsaturated fatty acids in lichen plantations. This explains the different sensitivity of the lichen. The sensitivity of lichens against a variety of air pollutants is due to morphological, physiological differences:

Due to the lower chlorophyll content its growth is slow and thus regeneration capability is limited. The water balance of lichens almost entirely depends on the air humidity and rainfall, thereby the regeneration time of assimilation is short. The autotrophic algae cells are capable of photosynthesis, hyphae can take up organic matter. Lichens are sensitive indicators of changes in environment so they can be used in indirect biologic monitoring. Lichen species are formed from the symbiosis of unicellular or filamentous green or blue- algae and ascomycetes (KOVÁCS EL AL., 1986; FARKAS, 2007).

MATERIAL AND METHOD

In the study Cladonia lichen plantations were collected from the untouched territory of the Kiskunsági National Park. In order to stimulate different environmental contamination the colonies were exposed to different environmental stresses (toxic gases SO_2 and NO_2 and toxic heavy metals: Cd, Cr, Cu, Ni, Zn, Pb. The experiments were carried out in enclosed space (0.3 m^3 tank) with 0. 2, 4, 6, 8, and 10-hour duration of treatment (in 100 mg / l).
In order to follow the accumulation of toxic elements lichen colonies we placed in a major transportation hub of Kecskemét in a grassy field. The exposure time was 90 days. As a control, we used lichen colonies from Kiskunsági National Park. In both areas, four repetition were used. The toxic elements were as follows: As, Cd, Co, Cr, Mo, Ni, Pb and Se.

The measure of the photosynthesis of lichen colonies by fluorescence indication method
The principle underlying chlorophyll fluorescence analysis is relatively straightforward. Light energy absorbed by chlorophyll molecules in a leaf can undergo one of three fates: it can be used to drive photosynthesis (photochemistry), excess energy can be dissipated as heat or it can be re-emitted as light-chlorophyll fluorescence. These processes occur in competition, such that any increase in the efficiency of one will result in a decrease in the yield of the other two. Hence, by measuring the yield of chlorophyll fluorescence, information about changes in the efficiency of photochemistry and heat dissipation can be gained.
Although the total amount of chlorophyll fluorescence is very small (only 1 or 2% of total light absorbed), measurement is quite easy. The spectrum of fluorescence is different to that of absorbed light, with the peak of fluorescence emission being of longer wavelength than that of absorption. Therefore, fluorescence yield can be quantified by exposing a leaf to light of defined wavelength and measuring the amount of light re-emitted at longer wavelengths. It is important to note, however, that this measurement can only ever be relative, since light is inevitably lost. Hence, all analysis must include some form of normalisation, with a wide variety of different fluorescence parameters being calculated.
One modification to basic measuring devices, that has been instrumental in revolutionizing the application of chlorophyll fluorescence, has been the use of a ‘modulated’ measuring system. In such systems, the light source used to measure fluorescence is modulated (switched on and off at high frequency) and the detector is tuned to detect only fluorescence excited by the measuring light. Therefore, the relative yield of fluorescence can now be measured in the presence of background illumination, and, most significantly, in the presence of full sunlight in the field. Most modern fluorometers use such modulated measuring systems and anyone considering investing in a fluorescence system is strongly advised to select a modulated fluorometer (GOVINDJEE, 1995).

The toxic element content tests were performed in the Laboratory of Kecskemét College Faculty of Horticulture College according to accredited soil and plant testing standards. The lichen samples were washed thoroughly and dried at 70 °C in a drier. Then, the air-dried leaf samples were homogenized by grinding. Fort the elemental analysis the powdered samples were exposed to microwave disruptors in the presence of nitric acid and hydrogen peroxide (Milestone Ethos Plus). The examination of the most important types of toxic elements was carried out by Ultima 2 inductive plasma atomic emission spectrometer (ICP-AES device).

RESULTS

We assessed the effectiveness of photosynthesis of lichen colonies based on chlorophyll fluorescence measurement. The results of the measurements are shown in the *Table 1* and are illustrated in *Figure 1*.

Table 1. The influence of SO_2 és NO_2 on the effectiveness of (PSII) yield (Fv/Fm)

Hours after treatment	Fv/Fm		
	control	SO_2	NO_2
2	0,63	0,50	0,58
4	0,64	0,32	0,56
6	0,62	0,25	0,50
8	0,61	0,20	0,48
10	0,63	0,18	0,45

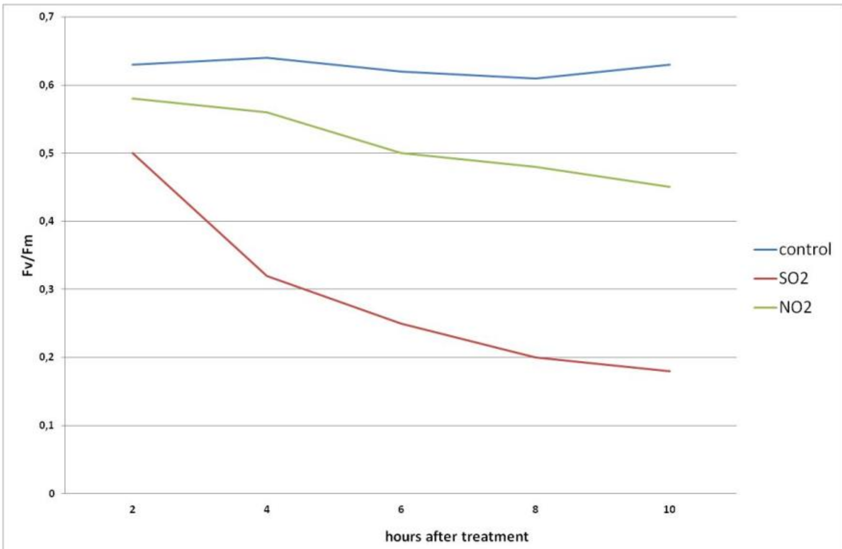

Figure 1. Photosynthetic activity induced by toxic gases

Table 2. The effect of toxic elements on the chlorophyll fluorescence of lichen colony (in 100 ppm concentration)

Hours after treatment	Fv/Fm						
	Cd	Cr	Cu	Ni	Pb	Zn	control
2	0,60	0,58	0,57	0,55	0,58	0,54	0,63
4	0,58	0,52	0,50	0,48	0,50	0,50	0,62
6	0,50	0,50	0,45	0,40	0,48	0,41	0,61
8	0,45	0,47	0,40	0,35	0,40	0,30	0,64
10	0,40	0,41	0,32	0,35	0,30	0,19	0,60

The accumulation of toxic elements in lichen colonies placed in public areas is presented in *Table 3*. Cadmium accumulation was extremely high lead, chromium and arsenic content also increased significant. The cobalt, selenium, nickel and molybdenum content remained practically unchanged.

Table 3. The accumulation of toxic elements in lichen colonies (mg/kg total elements expressed in dried solids (LOQ (Limit of Quantification): 0,500 mg/kg dry solids)

	As	Cd	Co	Cr	Mo	Ni	Pb	Se
K-1	0,637	18,4	0,544	26,3	<0,500	11,8	38,2	<0,500
K-2	0,751	19,8	0,558	28,0	<0,500	8,74	41,4	<0,500
K-3	0,706	14,1	<0,500	21,5	<0,500	7,49	31,5	<0,500
K-4	<0,500	18,5	<0,500	21,7	<0,500	5,99	37,5	<0,500
N-1	<0,500	<0,500	<0,500	9,89	<0,500	7,70	6,53	<0,500
N-2	0,532	<0,500	<0,500	11,5	<0,500	9,58	5,09	<0,500
N-3	<0,500	<0,500	<0,500	10,8	<0,500	9,74	5,44	<0,500
N-4	<0,500	<0,500	<0,500	10,2	<0,500	9,44	4,84	<0,500

K-1 – K-4: samples placed in public area; N-1 - N-4: Cladonia samples in the National Park

Lichen colonies were collected from the Kiskunsági National Park (*Figure 2*) and were placed in Kecskemét Budakapu Crossing (*Figure 3*). This later placed is heavy polluted because of the traffic.

Figure 2. *Cladonia magyarica* lichen colonies on sand dunes (photo Pölös)

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Figure 3. Kecskemét Buda Kapu Crossing (a contaminated place by toxic elements) (photo Pölös)

CONCLUSIONS

The following conclusions can be drawn from the results:

- the effects of toxic elements caused by gases of vehicles are well detectable by Fv / Fm fluorescence parameter of photosynthesis.
- lichen colonies are primarily sensitive to sulphur dioxide gas and toxic elements from the copper, zinc and lead.
- we studied the enrichment of toxic elements in Cladonia lichen colony in urban areas / K-labelled samples / Kiskunsági National Park and / N-labelled samples /samples from Fülöpházi sandy dunes Kecskemét.
- in contaminated urban environment sites lead, chromium, cadmium and arsenic toxic elements were accumulated in lichen. These values were in substantially lower, minimal concentrations or absent in the lichen samples the National Park were.

REFERENCES

KOVÁCS M., PODANI J., TUBA Z., TURCSÁNYI G. (1986): A környezetszennyezést jelző és mérő élőlények. Mezőgazdasági Kiadó, Budapest , 191 p.

FARKAS E. (2007): Lichenológia: a zuzmók tudománya. MTA Ökológiai és Botanikai Kutatóintézete kiadványa, Vácrátót, 193 p.

GOVINDJEE (1995): Sixty-three years since Kautsky: clorophyll a fluorescence. Aust. J. Plant Physiol. 22. 131-160.