STUDY OF ANTARCTIC LICHENS AS ENVIRONMENTAL BIOMONITORS IN THE ADMIRALTY BAY: PRELIMINARY STUDY OF TRACE ELEMENTS CONTENTS BY NEUTRON ACTIVATION ANALYSIS

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ABSTRACT

Al, As, Cu, Fe, Mn and Ti contents were analyzed for the epilithic antarctic lichen *Usnea antarctica*, used as a biomonitor for air quality. The samples were taken in the surrounding area of the Peruvian scientific station "Machu Picchu" on King George Island, in the Southern Shetland Archipielago (Antarctica). These elements have been assayed by Neutron Activation Analysis (NAA). The preliminary obtained results support the hypothesis that an atmospheric circulation of chemicals exists on the assessed area and the activities developed at the different scientific stations located on this island would be a potential source of chemical pollutants for the evaluated area.

1. INTRODUCTION

Environmental research on antarctic ecosystems is becoming of great interest for the international scientific community in recent years (Honda *et al*. 1987).

The use of biological indicators to evaluate the time-trend of pollutants in the environment has shown to be a successful tool (Phillips, 1980). In this way, lichens have been recognized as good bio-accumulators of atmospherically-transported heavy metals (Tomassini, *et al.* 1976).

The present preliminary study is about the assessment of the anthropogenic activities impact on an area of King George Island by the determination of several elements (Al, As, Cu, Fe, Mn and Ti) in the lichen specie of the region: *Usnea antarctica*.

2. MATERIAL AND METHODS

During the Summer Antarctic Cruise 2000 (Antar XI), samples of the lichen specie *Usnea antarctica* were collected in the surrounding area of the Peruvian scientific station "Machu Picchu" on King George Island, located at 62°05´S, 58°28'W in the Southern Shetland Archipielago.

The work was divided in two study areas: one of them, closer the station following wind direction, probably more influenced by human developed activities than the other. The samples were collected between January and February 2000, kept individually in plastic bags and stored in a thermic box to be transported to the scientific station.

Samples were identified, individually kept in plastic bags and stored at -5 °C, for their conditioning and treatment in the laboratory. There, samples were washed with bi-distilled water and dried at 20 °C for 24 hours. Then, samples were homogenized using liquid nitrogen, ground, sieved and stored in small glass recipients.

Elements contents were measured by Neutron Activation Analysis (NAA) in the Chemistry Department of the Instituto Peruano de Energía Nuclear (IPEN) in Lima, Peru. Analytical quality was checked using a reference material (Lichen IAEA-336). Comparisons between the obtained results from different areas were developed through one-way analysis of variance (ANOVA) and Pearson´s Correlations.

3. RESULTS AND DISCUSSION

Contents of Al, As, Cu, Fe, Mn and Ti were determined in specimens of *Usnea antarctica* from the surrounding area of the "Machu Picchu" station (Table 1). The international

literature (e.g Market, 1995) has remarked the suitability of *Usnea* as a sentinel organism, considering its antarctic and continental distribution, and so it allows comparison of the possible effects that anthropogenic activities (characteristics from different areas) could have on the plants.

The analysis of the obtained results of Al in both study areas, has shown that no significant differences (α=0,05) exist between them, and their corresponding average values were 797,14 $\pm$ 555,28 μg/g and 1015,25 $\pm$ 558,58 μg/g respectively (Table 1).

No significant differences (α = 0,05) have been obtained between the As concentrations (Table 1). In this way, the average concentration of arsenic as obtained for study area 1 was 0,66 $\pm$ 0,31 μg/g while for area 2 the corresponding mean value was 1,20 $\pm$ 0,28 μg/g.

The obtained data show that *Usnea antarctica* has accumulated more Cu at study area 2 and their differences in Cu concentrations were significant (α=0,05). Thus, the average Cu value for area 1 was under the Minimum Detectable Concentration, while the corresponding mean value for area 2 was 15,75 $\pm$ 6,66 μg/g (Table 1). These copper levels were significantly higher than the data reported by Poblet *et al*. (1997) for the lichens *Usnea auranticoatra* and *Usnea antarctica* from the 25 de Mayo Island in the Southern Shetland Archipielago, Antarctica.

The obtained data show that *Usnea antarctica* has accumulated more iron in study area No.2, but their differences in Fe concentrations were no significant (α=0,05). Thus, the average Fe value for area 1 was 716,86 $\pm$ 342,51 μg/g while the corresponding mean value for area 2 was 1260,25 $\pm$ 311,37 μg/g. These levels of Fe were higher than those previously reported by Poblet *et al*. (1997) for the lichens *Usnea auranticoatra* and *Usnea antarctica* from the 25 de Mayo Island in the Southern Shetland Archipielago, Antarctica.

In the general analysis, *Usnea antarctica* has shown to have similar Mn concentrations in both areas, with average values of 12,64 $\pm$ 7,78 μg/g and 14,28 $\pm$ 7,06 μg/g respectively but the concentrations are not similar to those previously reported by Saeki *et al*. (1977) and Poblet *et al*. (1997).

No significant differences have been recorded between the titanium concentrations (Table 1). In this way, the average concentration of Ti was recorded for study area 1 was 62,29 $\pm$ 38,74 μg/g while for area 2 the corresponding mean value was 97,50 $\pm$ 58,86 μg/g.

Although only the copper showed significant differences (α=0,05), in the Fig.1 we can appreciate qualitatively that all the elements are found in more concentration in the study area 2, because this area receives the discharge of the gaseous emissions released by the electric generator of the scientific station. However, since all the activities in the Machu Picchu station are developed in January and February of every year, the environmental impact has not been significant yet.

4. CONCLUSIONS

The preliminary results show that most of the analyzed trace elements can be accumulated by the *Usnea antarctica,* indicating that during their growth they have been exposed to these pollutants atmospherically transported to the assessed areas. This conclusion is sustained considering that it is largely known that lichens have neither roots nor other kind of adsorptive structures, and consequently for mineral nutrition they largely depend on atmospheric depositions (Bargagli, 1989). These results have shown that *Usnea antarctica* is useful to identify patterns of deposition of heavy metals atmospherically transported, and so it would be possible to study variations in the spatial distribution of these elements, not only at local but at regional scale.

Since the present work is a preliminary study, it is necessary to make new samplings and more analysis to have reliable less dispersed and better data. However, we have been able to verify qualitatively that an environmental impact exists for gaseous discharges to the atmosphere due to the human activities developed in the Peruvian Scientific Station "Machu Picchu". Finally, it is necessary to outline the suitability of lichen *Usnea antarctica*, to be used in monitoring programmes directed to evaluate the environmental quality of antarctic ecosystems.

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Table 1. Geographical distribution of metals ($\mu g.g^{-1}$ dry wt.) in *Usnea antarctica* from Peruvian Scientific Station "Machu Picchu" (2000).

Element	*Study Area*	*Mean ($\mu g.g^{-1}$)*	*Standard Uncertainty*	*Confidence Intervals (α= 0,05, k=2)*
Al	1	797,14	277,64	241,87 – 1352,42
	2	1015,25	279,29	456,67 – 1573,83
As	1	0,66	0,15	0,35 – 0,96
	2	1,20	0,14	0,93 – 1,47
Cu	1	< 10,00	< 10,00	< 10,00
	2	15,75	3,33	9,09 – 19,05
Fe	1	716,86	171,26	374,24 – 1059,37
	2	1260,25	311,37	637,52 – 1882,98
Mn	1	12,64	3,89	4,87 – 20,42
	2	14,28	3,53	7,22 – 21,34
Ti	1	62,29	19,37	23,54 – 101,03
	2	97,50	29,43	38,64 – 156,36

Table 2. Analysis of variance (ANOVA) between distribution of elements ($\mu g.g^{-1}$ dry wt.) in *Usnea antarctica* from Peruvian Scientific Station "Machu Picchu" (2000).

Element	*F calculated*
Aluminium	0,2612
Arsenic	0,7501
Cooper	5,7057*
Iron	3,6343
Manganese	0,0786
Titanium	1,1435

***F critic (α=0,05) = 5,1174**

Table 3. Pearson´s correlation among Al, As, Cu, Fe, Mn and Ti for the 11 sampling points distributed in the two study areas of the Peruvian Scientific Station (2000).

	Al	***As***	***Cu***	***Fe***	***Mn***	***Ti***
Al	1,000					
As	0,388	1,000				
Cu	0,233	0,584	1,000			
Fe	0,845*	0,634*	0,482	1,000		
Mn	0,966*	0,332	0,196	0,810*	1,000	
Ti	0,936*	0,551	0,218	0,924*	0,905*	1,000

(*): Significant correlation (p<0,05)

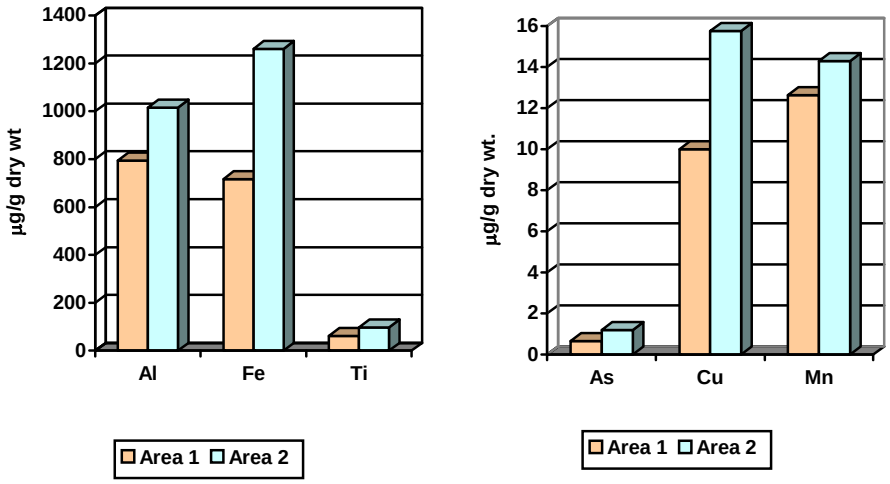

Figura 1. Geographical distribution of metals in *Usnea Antarctica.*