PRELIMINARY MAGNETIC MONITORING IN MAR DEL PLATA (ARGENTINA) USING LICHENS AS BIOMONITORS

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ABSTRACT

The objective of this work was the evaluation of the environmental pollution within the urban area of Mar del Plata (Argentina), using lichen species as biomonitors. Sampling campaigns were realized in 3 green areas located on the city centre, close to main avenues, where vehicular emissions are considered the main pollution source. The collected species was *Parmotrema pilosum* and magnetic properties were determined using environmental magnetism measurements: magnetic susceptibility, anhysteretic and isothermal remanent magnetizations. Associated parameters and ratios were calculated and used. The results showed that magnetite-like minerals are the main magnetic phase with a grain size distribution ranging between 0.1 and 1 μm.

Keywords: Biomonitoring, Magnetic properties, Lichen, Air pollution

RESUMEN

El objetivo de este trabajo fue evaluar la contaminación ambiental dentro del área urbana de la ciudad de Mar del Plata (Argentina), utilizando líquenes como biomonitores. Las campañas de muestreos se realizaron en 3 plazas céntricas ubicadas sobre avenidas, considerándose las emisiones vehiculares como la principal fuente de contaminación. La especie colectada fue *Parmotrema pilosum*. Las propiedades magnéticas fueron determinadas utilizando mediciones de magnetismo ambiental: susceptibilidad magnética, magnetización remanentes anhistérica e isotérmica. También se utilizaron sus parámetros y cocientes asociados. Los resultados mostraron la predominancia de minerales del tipo magnetita como fase principal magnética y su distribución de tamaños magnéticos varió entre 0.1 y 1 μm.

Palabras Clave: Biomonitoreo, Propiedades magneticas, Liquen, Contaminación ambiental

Introduction

Lichens receive nutrients for its vital process, from rain and dried deposition of particles in the air. In addition, they have a high retention capacity for metal deposition due to absence of cuticle and root system *(*Adamo *et al., 2003*), and due to this they can be considered good indicators for environmental pollution.

Lichens are known to be sensitive to various pollutants and are considered good biological indicators of air quality, and thus they are widely used in biomonitoring research, the application of magnetic methods with respect to this bioindicator was reported only in few study cases (Jordanova *et al,*. 2010*;* Salo *et al.,* 2012*;* Chaparro *et al.,* 2013*).* Rock- magnetic methods has been successfully applied to biomonitoring and can be

considered as alternative methods in evaluating air-pollution.

Methods and sampling

This work was realized in Mar del Plata (38º00.5'S; 57º33'W, Argentina, Fig. 1). Sampling campaigns were carried on 3 green areas on the city centre close to avenues with important vehicular traffic. The coordinates of collection sites were recorded using a Graming GPS device. The lichens were carefully removed using wood stools to avoid magnetic contamination, stored in paper bags to avoid the plant damage and to prevent the formation of lichenicolous fungi. The collected samples were dried in a stove at 25°C for two days and then they were crushed using a hand grinder with plastic blade. After that, the grinding material was placed in plastic containers, which was firmly pressed to prevent the movement of the material into the sample container.

Magnetic measurements were carried out in the Laboratory of Magnetism at CIFICEN-IFAS (Tandil, Argentina). These measurements were: mass-specific magnetic susceptibility (χ), anhysteretic and isothermal remanent magnetization (ARM and IRM). Several related magnetic parameters such as S-ratio (IRM_{-300}/SIRM), remanent coercivity (H_{CR}), χ_{ARM}/ χ-ratio, the King's plot (χ_{ARM} versus χ) and Day's Plot were also studied. Thermomagnetic measurements were carried out on samples using a home-made horizontal magnetic translation balance built in the Laboratory of Paleomagnetism at the Centro de Geociencias UNAM, Querétaro, México.

Lichen samples without any magnetic extraction were examined by scanning electron microscopy (SEM) using a Phillips microscope, model XL30. This microscope also allowed to analyse the elemental composition of each specimen by X-ray energy dispersive spectroscopy (EDS) with an EDAX model DX4 (detection limit 0.5%).

Results

The IRM studies and S-ratio (0.86 – 1) indicate the predominance of ferrimagnetic minerals for all samples. The H_{CR} values present a range between 27.5 and 36.9 mT, which correspond to magnetite mineral. Hysteresis parameters (H_C, H_{CR}, ratios M_{rs}/M_s, H_{CR}/H_C) calculated from hysteresis loops for representative samples indicate the predominance of pseudo single domain (PSD) magnetite minerals. The analysis of thermomagnetic curves (M (T)) between room temperature and 720ºC shows different slopes along them. The heating runs show M (T) changes starting at about 400 °C, suggesting the presence of other magnetic minerals. These results suggested the dominance of magnetite (T_C = 560-570 °C) and the additional presence of maghemite and/or hematite (T_C = 690 ºC).

The magnetic grain size was estimated from the King's Plot. Most of the samples (Rocha, San Martín and Mitre green areas) present magnetic grain size between 0.2 and 1 μm. Finer magnetic grains of 0.1 μm are observed for Mitre samples collected close to streets.

The SEM studies show spherules, irregular-shaped and aggregate particles of different shapes and sizes. In addition, the presence of elements such as Fe, Ti, Al, Si, Sn and W and low quantities of Mg, Ba and Cu were detected by EDS analysis.

The concentration-dependent parameters as, χ, ARM and SIRM showed a range values between 60.9 – 214.5 $\times 10^{-8}$ m^3 kg^{-1} (see the distribution in Fig. 1), 198.1-750.2 $\times 10^{-6}$ A m^2 kg^{-1} and 6.6-29.3 $\times 10^{-3}$ A m^2 kg^{-1}, respectively. The highest values of χ, were recorded close to avenues with high traffic (214.5 $\times 10^{-8}$ m^3 kg^{-1}), and the lowest on a closed road (60.9 $\times 10^{-8}$ m^3 kg^{-1}).

Conclusion

The magnetic measurements indicate that PSD magnetite is the dominant mineral for all samples. Thermomagnetic results indicated the presence of magnetite and additional minerals as hematite and/or

maghemite.

The spatial distribution of χ shows a decrease in magnetic concentration from sites close to main avenues toward the centre of the green area. Magnetic grain size estimation (0.2-1 μm) using the King's plot is in agreement with SEM observations.

Figure 1: Mar del Plata (38º00.5'S; 57º33'W, Argentina) and the studied green areas. In each area, the collecting sites and main avenues are displayed. Measurements of the concentration-dependent magnetic parameter (χ) on lichen (*Parmotrema pilosum*) samples are represented with red points.

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