Multivariate Analysis Contribution to Evaluate Anthropogenic Inputs of Chemical Elements in Lagoon Sediments

M. I. Prudêncio[1], M.I. Dias[1], F. Ruiz[2], M. Santos[2]

[1]Instituto Tecnológico e Nuclear, EN 10, 2686-953 Sacavém, Portugal
[2]Dep. Geodinámica y Paleontología, Univ. Huelva, 21071 Huelva, Spain

Abstract

In order to evaluate anthropogenic inputs of trace elements contaminants in lagoon environments to natural background, a multivariate analysis complementing geochemistry was done. A case study of lagoon sediments from NE Tunisia (EL Melah) is presented, identifying pollutants, and the main factors of environmental disequilibrium, in a view to its social and natural better management.

The absolute values of trace elements contents, the elements/Al ratios and enrichment factors of trace elements, calculated relative to Al and using an internal reference sample, were studied with a multivariate approach. Among the trace elements analysed, the statistical approach allowed to identify the elements with diverse distribution patterns (Cu, Ni and Zn) due to pollutant sources, in particular deposits of urban solid wastes and a purifying station.

Introduction

The major part of heavy metals introduced into an aquatic system are deposited in the sediments due to physic-chemical processes, thus these type of geological materials plays a very important role in the detection of sources of pollution in aquatic systems.

The identification of naturally elevated metal concentration is important because some trace elements appearing to be enriched may be only due to their geological source. Taking into account the natural variations in lagoon sediments, the compositional data must be interpreted not only using absolute concentration values in isolation, but also after a normalisation procedure which enables a more effective interpretation [1, 2].

In this work sediments collected from different environments of El Melah lagoon area were studied. Absolute chemical contents data, normalised values relatively to Al (conservative element), and enrichment factors (EF) were used as variables in multivariate analysis, that together with geochemical considerations, aims contributing to environmental quality evaluation.

Materials & Methods

Thirty one surface sediments (0-15 cm), collected in 2001 and 2003 in El Melah lagoon area (NE Tunisia), were analysed by using instrumental neutron activation analysis and inductively coupled plasma-optical emission spectrometry. Chemical contents were obtained for: As, Ba, Cd, Co, Cr, Cu, Mn, Ni, Pb, Sb, Sr, V, Zn, Al, Ca, Fe, K, Mg, Na, P, S and Ti.

Aiming an internal "non polluted reference sample" four sites were chosen for in depth coring. To normalise geochemical data the more pristine site among the four selected locations (the one with lower variation from deeper levels to surface) was identified, and use the respective deeper sample as the internal reference sample. The EF in all surface sediments compared to the internal reference sample were calculated relatively to Al ($EF_X = [X/Al]_{sample} / [X/Al]_r$). Analytical errors and natural processes may shift the EF, therefore in this work the EF<3 are assumed as natural background variation.

Multivariate statistical clustering methods were employed by using the Statistica program [3], namely the joining tree-clustering method.

Results

Correlation between variables (Pearson's coefficient) by using the UPGMA method was studied for absolute values (Fig. 1) and elements/Al ratios (Fig.2).

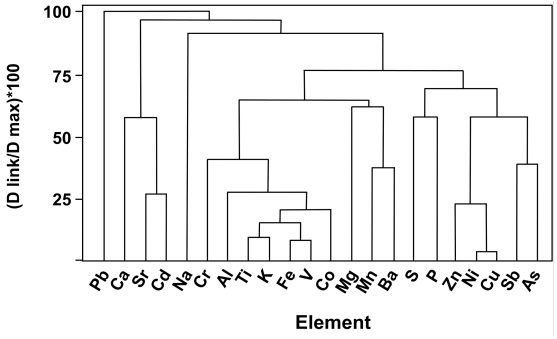

Fig. 1 - Hierarchical tree – clustering of chemical contents

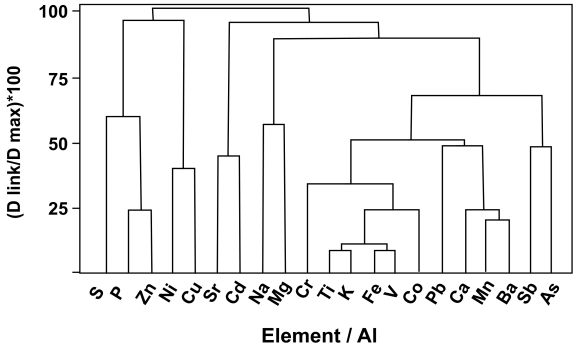

Fig. 2 - Hierarchical tree – clustering of chemical contents normalised to Al

Statistical analysis using the EF of all chemical elements of the surface sediments as variables, gave similar results to those obtained by using the element/Al ratios, indicating that the reference sample chosen can be considered an appropriate reference sample.

After normalisation (Fig. 2) Zn is correlated with S and P, as well as Ni and Cu at a lower level of similarity, probably through bindings of these trace elements with intermediate and hard bases; Co and Cr appear to be incorporated and/or adsorbed onto iron hydroxide phases and clay minerals, since a correlation with Al, Ti, K, Fe, V was found. Pb is more correlated with Mn suggesting its presence mainly in Mn hydroxides; and Cd is more correlated with Sr. It should be noted that this analysis shows a clear distinction between Zn, Ni and Cu, and all the other trace elements.

Conclusions

The results obtained for El Melah surface sediments allowed to characterize and differentiate diverse sub-environments in the lagoon area.

Multivariate analysis has played an important role in contributing to evaluate anthropogenic inputs of chemical elements in lagoon sediments, showing that in general trace elements are within background levels, except Ni, Cu and Zn, considered very toxic. These elements are enriched in the confined zone adjacent to the Slimene treatment station and not correlated with other transition elements, pointing to an anthropogenic input.

Acknowledgments

The financial support of the European Union (Project ICA3-CT-2002-10012 COLASU "Sustainability of Mediterranean Coastal Lagoon Ecosystems Under semi-arid climate") is gratefully acknowledged.

References

1) K. Loska, D.Wiechula, I. Korus, Metal contamination of farming soils affected by industry. *Environment International*, 30, (2004) 159-165.
2) C.F. Conrad, C.J. Chisholm-Brause, Spatial survey of trace metal contaminants in the sediments of the Elizabeth River, Virginia. *Marine Pollution Bulletin*, 49, (2004) 319-324.
3) StatSoft, Inc. STATISTICA (data analysis software system), version 6 (www.statsoft.com), 2003.