ENVIRONMENTAL CHARACTERIZATION OF THE ALBUFEIRA LAGOON (PORTUGAL) AT MICRO TIMESCALE USING A MULTIDISCIPLINARY APPROACH (TALK)

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Introduction

The Albufeira lagoon is located 20km south of Lisbon, in the coastal arc of Trafaria-Espichel (Fig. 1A) and is formed by two main bodies – Lagoa Grande and Lagoa Pequena (Fig. 1B); its major axis is oblique to the coast (trending NE-SW), the flooded surface is 1.3km^2 and its maximum length, width and depth are 3.5km, 625m and 15m, respectively. It is usually isolated from the ocean by a welded sand barrier, where a tidal inlet is artificially opened once a year, allowing the renewal of the lagoonal water. In consequence, the lagoonal water becomes homogeneous and similar to marine water. When the inlet is closed, the lagoon essentially collects freshwater from the tributaries leading to stratification of the water column.

In the late 70's an intensive raft culture of mussel (*Mytilus edulis*) was introduced at Albufeira lagoon. The intensive culture of filtering organism in low-energy environments may raise particular sustainability problems, such as changes in sedimentation rates (Schettini *et al*., in press), in sediment organic content and in nutrient cycles.

The main goal of this work is to characterize the Albufeira lagoon at micro timescale using a multidisciplinary approach; a number of parameters that are important to establish present day environmental conditions and to understand actual dynamics of this lagoon have been assembled to build an integrated data base; in turn, these elements are of crucial importance to the interpretation of past sedimentary registers and help to build models of paleoenvironmental evolution of lagoonal areas.

Methods

The micro timescale approach referred to in this work relied upon the study of bottom sediments sampled in 2003 during two surveys – february/march, shortly before barrier breaching at the end of a long period of isolation from the ocean, and june, following a period of inlet activity and exchange with the ocean. In each survey, 20 sediment samples were collected (Fig. 1b) using a Van Veen grab sampler operated from a small boat.

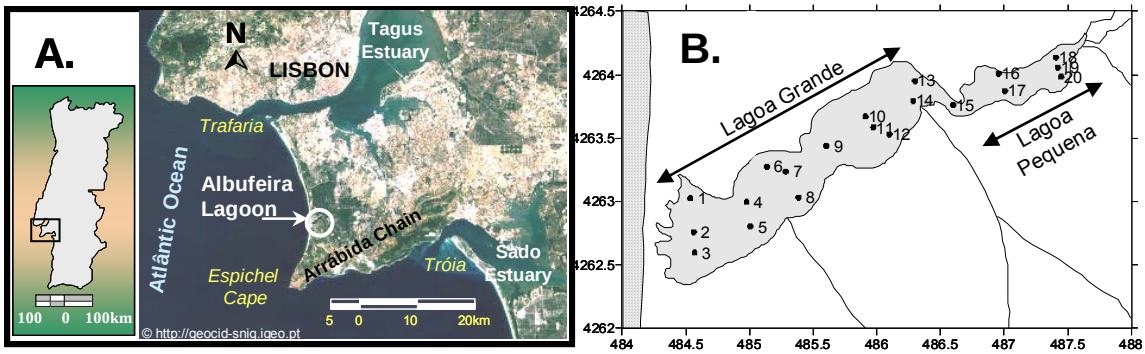

Figure 1 - A - Location of Lagoa de Albufeira in the coastal arc of Caparica-Espichel; B – The main bodies of Lagoa de Albufeira and location of sediment samples (UTM Coordinates, European Datum 50).

Sedimentological analysis (texture, pH - determined using the electrometric method according to Head (1980) and classified following Pratolongo (*in* Costa, 1999), organic matter

(OM) - determined through oxidation with potassium-dichromate followed by titration using iron-sulphate (Standard E-201, LNEC, 1967) and $CaCO_3$ content - determined gasometrically using an Eijkelkamp calcimeter) have been performed in all samples, whereas geochemical analysis (major and trace elements determined by EDXRF – Araújo *et al*., 2002) and quantification of the calcareous nannoplankton using the "settling" technique (Ferreira & Cachão, 2003) were carried out only in the first and second surveys, respectively. Dimensional and sorting (textural) classification of sand follows Friedman and Sanders (1978). The Enrichment Factor (EF), describing the relative concentration of elements in a given sample was calculated by Loring & Rantala, 1992:

$$EF = \left([Metal]_{\text{sample}} / [Al]_{\text{sample}} \right) \Big/ \left([Metal]_{AverageShale} / [Al]_{AverageShale} \right)$$

In order to evaluate the impact of the *Mytilus edulis* farming in this lagoonal system, particles settling through the water column have been collected in sediment traps, suspended during 7 days close to the bottom right under a raft in two occasions (July 2003): A – open-inlet conditions, at 11m depth and (B) – closed- inlet conditions, at 10m depth. This material was analyzed for sedimentological and paleocological purposes.

Results and Discussion

Similar textural and compositional results have been found in sediment collected in both surveys: in central and deeper zones of Lagoa Grande and Lagoa Pequena prevail muddy, neutral to subalkaline (pH 7.3 to 7.6) sediment, with important bioclastic ($CaCO_3$ ranging between 3 and 29%) and OM (3 to 7%) contents; in the vestibular area and fluvial fans of Apostiça and Aiana rivulets the sediment is essentially sandy, subalkaline (pH 7.6 to 8.5) with low content in OM (<2.1%) and $CaCO_3$ (<5%) (Fig. 2A,B). In the vestibular zone, coarse moderately to well sorted sand predominates, while in the alluvial fans sand is medium, moderate (Aiana) to moderately well sorted (Apostiça).

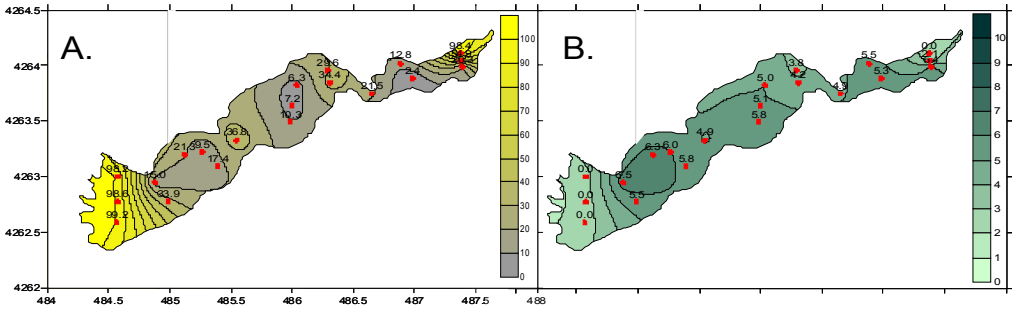

Figure 2 – Distribution of some sedimentological parameters in lagoonal bottom sediments collected in the second survey (June 2003): A – percentage particles >63μm; B – percentage of organic matter.

Values of major elements such as Si and Al are related to sediment mineralogy, and may be used as indirect markers of texture: essentially sandy sediments exhibit the highest values of Si (41-45%) and the lowest values of Al (1-3%), while muddy sediments are comparatively enriched in Al (4-9%), K and Rb (probably associated with mica) and naturally associate with other elements bearing affinity for organic and silt-clay fractions (e.g. heavy metals). Sediment with important bioclastic component is clearly identified by the highest concentrations in Ca (>1,6%) and Sr (>100mg/kg). As expected, fine sediment accumulated under the influence of the tidal inlet is enriched in marine-borne elements (Cl, Br and S).

To distinguish natural concentration from anthropogenic enrichment, Loring & Rantala (1992) suggested plotting concentrations of metals *versus* Al, and values that plot above the trend line of linear regression are considered as contaminated. Cr, Ni and Cu in Albufeira lagoon show high correlation values with Al (R^2 0.75, 0.89 and 0.88, respectively), suggesting natural occurrence for these elements, while Zn and Pb (especially the samples of Lagoa Grande and near Aiana alluvial fan) show lower correlation values (Fig. 3A), with enrichment factors that reach 2.4 and 5.1, respectively (Fig. 3B), indicating possible anthropogenic influence.

Calcareous nannoplankton content in bottom sediment displays a longitudinal gradient with maximum values ($6.2x10^6$ coccoliths/g) under the influence of tidal inlet and decreasing upstream. The identified assemblage was mainly composed by *Gephyrocapsa oceanica*, *Gephyrocapsa muellerae*, *Gephyrocapsa ericsonii* and *Emiliania huxleyi* with maximum values of 2.25 $x10^6$, 1.38 $x10^6$, 9.69 $x10^5$, and 7.62 $x10^5$ coccoliths/g, respectively. Sediment collected east of the outlet of Aiana rivulet is completely barren of coccoliths.

During the active-inlet period the materials collected in the trap located under the raft are essentially muddy (silt+clay >56%), subalkaline (pH 8.0-8.1), with OM content between 16 and 19% and exhibiting $16.5x10^6$ coccoliths/g. In closed-inlet conditions these deposits enriched in mud (silty+clay >75%) and OM content (22-25%), pH decreased of to neutral values (7.2-7.4) and the calcareous nannoplankton content dropped to $8.1x10^6$ coccoliths/g. The values obtained at 11m depth (active inlet) and 10m depth (inlet absent) for the flux of particulate suspended matter were 0.142 and 0.092 kg/m^2.day, respectively.

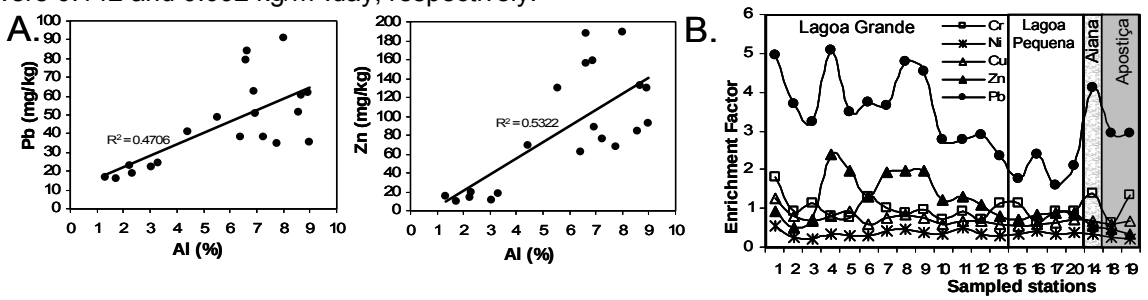

Figure 3 - A - Plot of Pb and Zn *versus* Al in bottom lagoonal sediment, and correlation coefficient (R^2); B – Enrichment Factor of bottom lagoonal sediments in different sampling sites.

Conclusions

Textural, compositional and geochemical results obtained from bottom sediment allow the definition of areas with different dynamic conditioned mainly by the efficiency of the tidal inlet and fluvial discharge. In the lagoonal central, low energy zones, muddy sediment predominate enriched in organic matter and bioclasts, and show high concentrations in Al, Ca and Sr, as well as in heavy metals. The proximity to the ocean and to a fluvial source, locally increase energy levels and the deposits accumulated there are essentially sandy and rich in Si. Zn and Pb are the only elements that suggest some degree of anthropogenic contamination, mainly in the Lagoa Grande, reaching FE of 2.4 and 5.1, respectively.

Mytilus edulis are filtering organisms responsible for the increase of vertical flux of OM from the water column to sediment in the lagoonal system. The results obtained in the Albufeira lagoon suggest that particulate suspended matter near the rafts is enriched in OM and coccoliths comparatively to bottom sediments elsewhere in the lagoon. When the lagoon looses capacity of mass exchange with the ocean the number of coccoliths in trapped sediment decreases and the OM content increases.

Acknowledgments

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