RESPONSE OF SHALLOW WATERS BENTHIC FORAMINIFERA TO ENVIRONMENTAL CHANGES AND ANTHROPOGENIC INFLUENCE IN CONCEIÇÃO LAGOON (SC), BRAZIL

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INTRODUCTION

The lagoons work in a complex environmental-biotic array and are vulnerable to human impact, which can provoke inputs of organic matter and nutrients. When the enrichment exceeds the carrying capacity, the primary production increase and can affect the communities distribution due to dissolved oxygen decrease.

All species reacting according to environmental changes and accumulate information during their life cycle. Some of them show characteristics that could be used to indicate environmental conditions and because of it they are wide used in environmental quality analysis.

Foraminifera are microfauna organisms that shows differences according physical and chemical conditions of recent and previous environmental changes (Duleba *et al.*, 2005), limiting the assemblage distribution and composition, controlling reproduction, growth and mortality (Murray, 2006).

Therefore, this study investigated the benthic foraminifera distribution in Conceição lagoon shallow waters, to evaluate different responses to terms of oceanographic and anthropic characteristics that these environments are subject.

MATERIAL AND METHODS

Study area and sampling regime

Conceição lagoon is located in east-central coast of Santa Catarina island, between 27^o34'S and 48^o27'W. It has a single channel connected with to the sea, meso- to polyhaline waters and sediments are mainly sandy in shallow areas and muddy in deep and central areas.

Two sampling surveys in sandy marginal areas (depth less than one meter) carried out on 27/11/2008 and 11/03/2009. These dates were initially chosen to evaluate the environmental conditions before and after the summer season, when occur a strong population increase. Nevertheless, an anomalous pluvial event in November 2008 (643.6 mm accumulated in the preceding 30 days of the samples against the 266.5 mm accumulated during the same period in the second sampling) was also an important tensor causing significant environmental changes. The sampling grid was defined in five sub-areas named 1-Canto da Lagoa, 2-Centrinho, 3-Canto dos Araçás, 4-Beco dos Coroas and 5-Rio Vermelho (Figure 1). In each

one, three sampling stations were placed totaling 15 stations in each survey. Surface sediment and column water samples were collected. Besides foraminifera studies, physical-chemical, nutrients and microbiological analysis were also conducted.
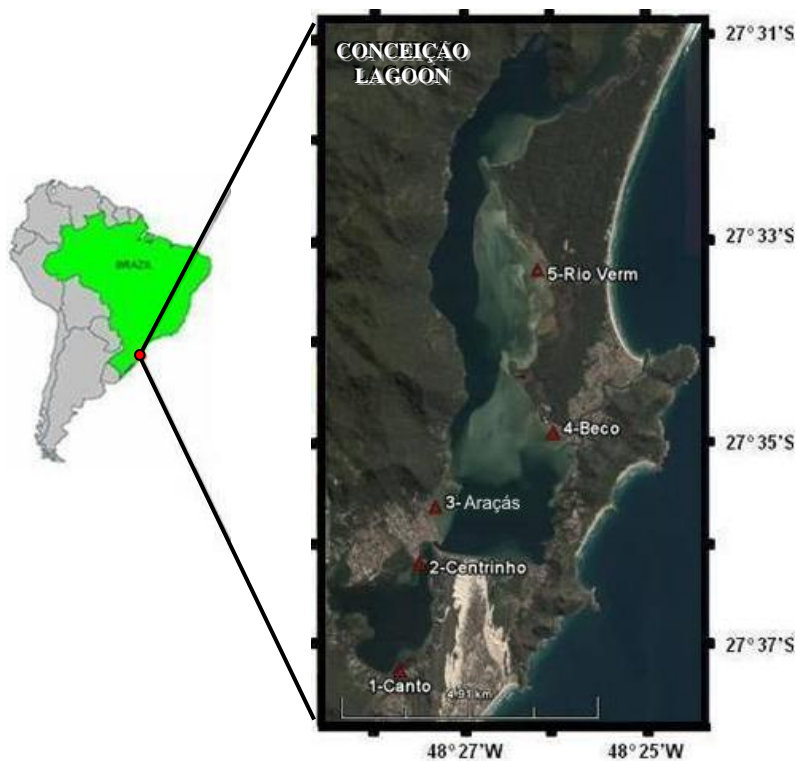
Figure 1. Location study and samples position at Conceição lagoon, south of Brazil.

Analytical and Statistical Procedures

Salinity, temperature, pH and dissolved oxygen were measured *in situ* using YSI-556MPS multi-parameter probe. The Dissolved Inorganic Nitrogen (DIN), reactive silica and orthophosphate concentrations followed Aminot & Chaussepied (1983) and Koroleff (1969). The analytical approach was based on UV-Vis spectrophotometer methods described in Baumgarten *et al.* (1996) and Niencheski *et al.* (2006). *Escherichia coli* were determined according Food and Drug Administration (1984).

The sedimentary organic matter and carbonate percentages was determined according Gross (1971). For the sediment size analysis was adopted the methods described in Suguio (1973) using 0.5 phi mesh sieves intervals.

Biological samples were processed according Boltovskoy (1965) and the taxonomic classification followed Loeblich and Tappan (1988). The distribution of the total assemblage (living plus dead) was used as dominant environmental indicator (spatial approach). Morphological abnormalities and ecological parameters derived from the living population were applied to analyze the sampling surveys changes (temporal approach).

To determine significant variations in different work scales (between areas and surveys) nonparametric ANOVA (Kruskal-Wallis and Dunn tests) was used. Principal Component

Analysis (PCA) was applied to determine sediment and biological parameters that best summarizes the lagoonal environmental variability.

RESULTS AND DISCUTION

Was identified 19 benthic foraminifera *taxa* and *Cribroelphidium excavatum* was the most abundant (57%). The species *Ammonia tepida* and *Ammotium salsum* also presented high abundance in the lagoon (12% and 16%, respectively).

Comparing the abundance with Debenay *et al.* (1998), that studied the foraminifera in Conceição lagoon ten years earlier, it is possible to observe some important assemblage differences. The authors described the shallow sandy areas composed by agglutinant assemblages of confined habitat: *Ammobaculites exiguus*, *Pseudoclavulina* sp., *Gaudryina exilis*, *Miliammina earlandi* and particularly *Ammotium salsum*. However in our study a rotaliids abundance increase was observed, as well as a change of the dominant specie *A. salsum* by *C. excavatum*. This species substitution may suggest a lagoon salinization process as well as reduction of sediment oxygen concentration.
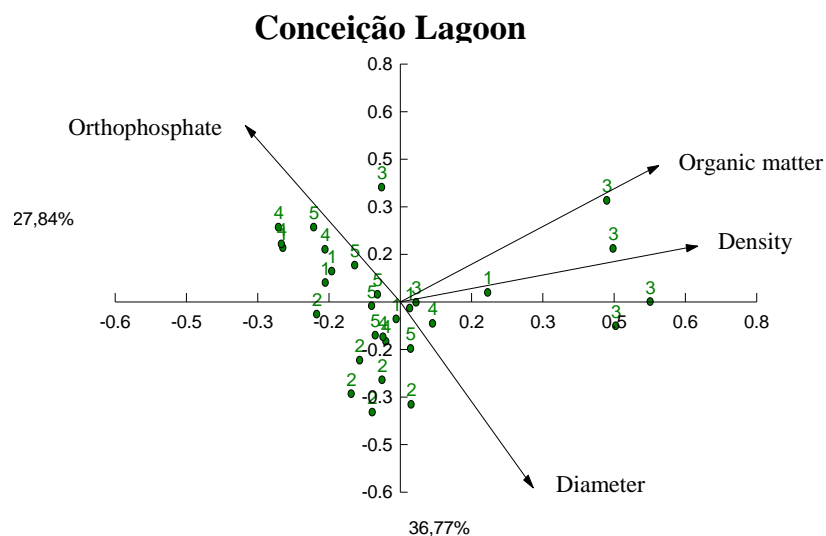
The foraminifera density in Conceição lagoon had a mean of 294 ± 381 individuals/50 mL (ranging from 8 to 1549 individuals/50 mL sediment). The area 2-Centrinho showed lower density in both sampling surveys and area 5-Rio Vermelho highest density in the second sampling (159 ± 94 live individuals/50 mL sediment), that may be related to the long distance of urban areas and the wave-sheltered site.

The malformations varied between 0 to 10% in the first survey and between 1 and 75% in second survey. The area 2-Centrinho showed the major percentage, however must be carefully analyzed due to be a low density. Anyway, this area is most susceptible to organic pollution caused by human density and may have an important ecological significance. The area 4-Beco presented malformations percentage above 5% and could suggest the existence of human tensors affecting negatively the assemblage.

Environmental gradient on Conceição lagoon

The areas in Conceição lagoon was analyzed using selected variables to construct a PCA. The criteria of selection were: (1) the variable must present little variation in time and (2) be strongly correlated to another descriptors.

Only four descriptors have been incorporated to PCA (Figure 2) but other descriptors very well related also contributed to discuss the gradient. The orthophosphate concentrations were positively correlated with salinity, temperature, dissolved oxygen and pH and negatively correlated with DIN levels and reactive silica, characteristics that indicate a similarity between areas 1-Canto and 4-Beco on these descriptors. The total organic matter vector may be also associated to carbonate value, characterizing 3-Araçás area as a single area differentiated by sedimentological composition and highest density. These characteristics may be related to favorable ecological conditions to the foraminifera assemblage. Finally the 2-Centrinho area approached the sediment diameter vector, indicating the occurrence of fine sediments (very fine sand). This descriptor is correlated to lower dissolved oxygen levels and higher NID concentrations, suggesting anthropogenic influence in the area (also corroborate by high levels of fecal coliform bacteria). The area 5-Rio Vermelho showed a central portion distribution in the graph, suggesting a weak correlation with the variables.

Conceição Lagoon

Figure 2. PCA showing relations between shallow areas and the principal environmental descriptors of Conceição Lagoon (sediment diameter; orthophosphate; total organic matter and density of foraminifera).

CONCLUSION

Despite the relative homogeneity of sedimentological characteristics, a spatial gradient of foraminifera distribution in the lagoon was found, reflecting the different hydrological conditions imposed by marine gradient confinement between areas and the local human impact. The biological analysis showed the dominance of *C. excavatum*, tolerant to different lagoonal conditions and consequently widely distributed. However other ecological descriptors were sensitive to spatial variations. The low densities and high malformation percentage tests could differentiate spatially 2-Centrinho to the others. These descriptors associated with a fine sediment suggest an ecological stress in this area. In contrast 3-Araçás was differed from the others by higher density and organic matter in sediments, indicating that a slightly organic enrichment can act positively on benthic foraminifera.

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