Biogeochemistry features of sediments from Cabo Frio upwelling system

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This paper was selected for presentation by an ALAGO Scientific Committee following review of information contained in an abstract submitted by the author(s).

Introduction
Coastal upwelling is a phenomenon characterized by uplift of cold deep nutrient-rich waters into the ocean euphotic surface layer in response of winds forces creating favorable conditions for high primary productivity. The most important upwelling zones are located off the west coast of South America, Africa and North America. In Brazil, the coastal region of Cabo Frio is characterized by the occurrence of unusual eastern upwelling system. The Cabo Frio Upwelling System (CFUS) is located in an area where there is a conspicuous change in the shoreline orientation, a predominance of northeastern trade winds, mainly during austral summer–spring, and synergetic oceanographic mechanisms favors the uplift of South Atlantic Central Water (SACW) resulting in different upwelling areas on the shelf (Belem et al., 2013).The production of organic matter in these systems is directly influenced by upwelling favoring the production and accumulation of organic-rich sediments. The main goal of this study is characterize the biochemistry and geochemistry of organic matter associated with bacterial activity in sediments cores (Box-cores and Kullenbergs cores).

Experimental
Twelve Box Core (BC) samples and four Kullenbergs cores (CF10-01C, CF10-04C, CF10-09C and CF10-15C) (Figure 1) were taken from continental Cabo Frio shelf. Total Organic Carbon (TOC) and Sulfur (S) content analyses were performed on a LECO SC144 device. The adopted methods were ASTM D 4239 (ASTM, 2008). Protein analyses were carried out according to Hartree (1972) a Rice (1982). Carbohydrates content were obtained according to Gerchacov and Hatcher (1972). Lipids were analyzed according to Marsh and Wenstein (1966). Esterase enzyme activity was performed according to Stubberfield and Shaw (1990). Determination of the electron transport system was made according to Trevors (1984) and Houri-Davignon (1989). Bacterial respiratory activity was analyzed using methodology described by Alef and Nannipieri (1995).Bacterial count was obtained according to Kepner & Pratt (1994).

Results and Discussion
Box Cores samples showed contents of TOC ranging from 0.63 to 1.47 wt% and sulfur (S) from 0.06 to 0.40%, and TOC:S ratio varied from 4.6 to 12.12. The Bacterial respiratory activity predominantly detected was aerobic, fermentation and denitrification. TOC:S ratio associated with the bacterial metabolism showed a clear preference of aerobic metabolism, which can classify the environment as sub-oxic to oxic. The quantification of biopolymers established averages of carbohydrates of 27.9 (± 8.86) mg.g⁻¹, proteins 9.9 (± 2.24) mg.g⁻¹, and finally the lipid with an average of 21.77 (± 3.61) mg.g⁻¹ and showed the following relationship: carbohydrate>lipid>protein. This relationship is considered normal for marine environment. The biopolymers also showed different distribution at the Cabo Frio shelf. High values of proteins and lipids were found on the nearshore samples and on the middle part of the shelf. On the other hand, high values of carbohydrates were found predominantly on the offshore samples. The electron transport system (ASTE) showed high concentrations and was detectable on all sampling station, while the esterase enzymes (EST) presented high values only offshore. The bacterial population observed was high, but no major changes in their biomass (≈10⁸-10¹⁰ cells.g⁻¹).

The samples of Kullenberg cores showed high mean values of TOC and S at the CF10-04C and CF10-09C (middle part of shelf). In contrast, low values were found at the CF10-01C and CF10-15C cores. The amount of biopolymers showed a peculiar distribution at the shelf with major values of carbohydrates for CF10-01C core, lipids for CF10-15C and proteins for CF10-04C and CF10-09C cores (Table 1). The relationship between biopolymers can be expressed by carbohydrate>lipid>protein for CF10-01C and CF10-15C cores and protein>carbohydrate>lipid for CF10-04C and CF10-09C cores. The formation of particulate organic carbon as a result of primary production plays a vital role in organic carbon accumulation at different rates in specific deposits along continental shelves (Sanders et al., 2014). The pattern of distribution of biopolymers indicates different origins of organic matter on CFUS.
Trevors, J. 1984. Effect of substrate concentration, inorganic nitrogen, O2 concentration, temperature and pH on dehydrogenase activity in soil. Water

<table>
<thead>
<tr>
<th>CF10-01</th>
<th>CF10-04</th>
<th>CF10-09</th>
<th>CF10-15</th>
</tr>
</thead>
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<tr>
<td>COT%</td>
<td>0.55</td>
<td>1.20</td>
<td>1.30</td>
</tr>
<tr>
<td>S%</td>
<td>0.32</td>
<td>0.54</td>
<td>0.51</td>
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<tr>
<td>CARBOHYDRATE mg.g⁻¹</td>
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<td>14.75</td>
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<tr>
<td>PROTEIN mg.g⁻¹</td>
<td>11.30</td>
<td>46.61</td>
<td>47.13</td>
</tr>
<tr>
<td>LIPID mg.g⁻¹</td>
<td>13.12</td>
<td>2.02</td>
<td>3.92</td>
</tr>
</tbody>
</table>

Table 1: Average values of geochemical and biochemical analyses on the cores of CFUS.

Conclusions
Based on these results, TOC and S values determined on CFUS samples are low when compared with other upwelling systems, but it is in agreement with previous studies developed at the same area. The presence of aerobic metabolism at the Box Cores samples may be related to availability of O2 brought by upwelling.
It was also found that the bacteria present in sediments in the region are metabolically active in the environment, with low energy expenditure breakdown of organic matter (OM), showing that OM is in abundance and ideal size for consumption (<600Da). The peculiar distribution of TOC, S, biopolymers and relationships among the biopolymers can indicate both different depositional systems and organic matter sources.

Acknowledgements
The authors are grateful to CNPq (National Council for Scientific and Technological Development) and ANP (National Agency of Petroleum Natural Gas and Biofuels) for scholarships; and to PETROBRAS-Brazil for the financial support through the project entitled “Produitividade na ressurgência costeira de Cabo Frio e seu potencial de acúmulo de matéria orgânica: Interação Biosfera – Geosfera”.

References