Temporal Variation of Bacteria Trough a Spring Tide Cycle on a Fixed Site at the Perequê Tidal Creek Paraná, Brazil

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ABSTRACT


Heterotrophic bacteria are important due to its capability of organic matter remineralization and also as a source of food for zooplanctonic organisms and suspension feeding animals. Although they possess a wide distribution, its importance is greater in coastal areas due to high input of organic matter and nutrients from the continent and also by anthropogenic influence. Tidal creek’s are systems of channels dominated by tide regime, constituting important ways of water circulation and particulate material. The Perequê tidal creek drains rainfall waters, underground waters and sewage from the populated area of Pontal do Sul. During the high tide it suffers the influence from the eutrophic waters from the continental shelf. The objective of the present research was to evaluate the influence of an entire cycle of a spring tide over bacteria found on this tidal creek. Hourly samples of surface waters were collected during a 25 hour period on April 09 and 10/2001 in a fixed site. The following parameters were evaluated: tide, water temperature, salinity, pH, dissolved oxygen, precipitation, wind, total heterotrophic bacteria, bacterial biomass, halophytic and halophagic heterotrophic bacteria, total coliforms and Escherichia coli. The present results showed that in these regions spring tides, especially in periods of intense rainfall, influenced the values of aerobic heterotrophic bacteria, total coliforms and E. coli. On the contrary, values of total heterotrophic bacteria were more elevated in high nocturnal tide on the April 10, when the influence of the cold front that preceded the sampling effort could not be observed.

ADDITIONAL INDEX WORDS: Coastal waters, bacteria, tidal creek.

INTRODUCTION

Heterotrophic bacteria can be found in all marine environments. They are capable of recycling organic matter and serve as food for filter-feeders and other zooplanktonic organisms. The majority of bacteria can be found in the photic zone and the sediment-water interface, due to respectively a larger accumulation of phytoplankton and the resuspension of matter (RHEINHEIMER, 1985). They have an important role in coastal regions (deltas, estuaries, bays and mouths of rivers) due to the input of organic substances and nutrients from terrestrial sources (GUNKEL, 1964; GOCKE, 1977; RHEINHEIMER, 1985), and from anthropogenic influences (cities, towns, ports, etc.) that modify them directly and indirectly and both quantitatively and qualitatively (KOLM AND ANDRETTA, 2003).

Marine bacteria can be found in coastal regions where they are adapted to environments of high salinity. The halotolerant bacteria are adapted to areas of intermediate salinity and halophobic bacteria are brougt from the river. This last group of bacteria are adapted to areas of intermediate salinity and halophobic bacteria are brougt from the river. (KOLM AND ANDRETTA, 2003).

KOLM AND ANDRETTA (2003) conducted the first bacteriological research in the Perequê tidal creek studying the influence of tides on bacterioplankton. The results obtained in this study demonstrate that during the study period the spring tides principally after periods of intense rains had an influence on the amount of reproducing aerobic heterotrophic bacteria, total coliforms, and Escherichia coli. However, the neap tides had an influence on total heterotrophic bacteria and the total bacterial biomass. The objective of the present research was to evaluate the influence of a complete cycle of a spring tide on the bacteria that can be found in surface waters of a tidal creek as well as analyzing the interrelation between the biotics and abiotics analyzed values.

METHODS

Tidal creeks has been defined by HACKNEY et al. (1976) as channels that drain mangroves and saltmarsh areas during the tidal cycle. FRENCH et al. (1993), define tidal creeks as a system of channels characteristic of coastal plains controlled by tidal cycles, constituting important ways in the exchange of water and particulate material.

The Perequê tidal creek (Figure 1) is located at the entrance of the Paranaguá Estuarine Complex (25°16’34”S; 48°17’42”W). It is nearly 2.6 km in length (LANA et al., 1989) and follows a typical meandering path, with the mouth of the river in the DNOS channel, located next to the access channel of the Paranaguá Bay in the high energy region of the estuary (BLANKENSTEYN, 1994).

For many years this place has suffered and continues to suffer from anthropogenic influences. In the central portion and at the mouth of a river part of its stream bed has been restored. Currently the largest impact affecting the system is the rain water drainage and sewage entering from the village of Pontal do Sul to the inner part and the marinas near the mouth of the river (KOLM AND ANDRETTA, 2003).

Between 11:00am on April 9, 2001 and 11:00am on April 10, 2001 (complete cycle of spring tide) surface water samples were collected each hour, comprising twenty-five samples in total, at a fixed point located in the Perequê tidal creek. Each sample was analyzed at the Laboratory of the Centro de Estudos do Mar/UFPR for each of the following parameters: temperature of the water (standard thermometer scales 1/40°C); salinity (refractometer Atago model S/MILL with scale of 0,40); pH (portable pHmeter Atago); dissolved oxygen (using the Winkler method); precipitation and wind (data provided by the Administration of the Ports of Paranaguá and Antonina); total heterotrophic bacteria (as described by PARSONS et al. (1984) and KOLM AND ANDRETTA (2003); bacterial biomass, through the quantification of the biovolume (BJÖRNSEN and KUPARINEN, 1991); aerobic heterotrophic bacteria (cultivating halophagic and halophilic according to the described methodology by KOLM AND CORREA (1994) and KOLM AND ARBEHYER (1995); total coliforms and Escherichia coli (method of Most Probable Number - MPN using the way of Colilert culture of the Idexx firm).
Temporal Variation of Bacteria Through a Spring Tide Cycle

KOLM and ANDRETTA (2003) had previously studied bacterioplankton along the Perequê tidal creek and had observed higher values of salinity, pH, and dissolved oxygen during high spring tide. Similar results had been observed in the present research where the highest values of these parameters were obtained during the diurnal high tide on April 9, 2001.

The highest observed temperatures, which were during the diurnal high tide on April 9, 2001 and at 11:00am on April 10, 2001, must be directly related to the collection schedules. MAAK (1981) characterized the paranaense coast as being tropical of transition. In this region a accentuated variation between nocturnal and diurnal ambient temperatures occurs influencing the temperatures of the water. Therefore it is foreseeable that the highest values of temperature occur near noon. However, on April 9, the highest temperatures were registered at 03:00pm and 04:00pm.

The majority of rain is caused by cold fronts moving from the south to the north provoking as a consequence reductions in both the temperature of air and superficial waters (KOLM and ANDRETTA, 2003). Therefore the high levels of rainfall registered on the days that had preceded these collections could have influenced the in situ maximum temperatures. One can conclude that the diurnal temperatures had been higher than the nocturnal temperatures but that the peak schedules can be modified by the meteorological conditions.

In a similar way, the highest salinity (30‰) was recorded at 04:00pm on April 9. The results of this sample indicate that the salt water intrusion was higher during the first high tide. The forecast for astronomical tides are based on calculations and do not take into consideration the meteorological tides. This must have influenced the observed results as during the time preceding this study a cold front with winds predominately from the north came from the south where traditionally forces the entrance of larger quantities of saltwater.

The frequency of cultivable heterotrophic bacteria, both halophagic and halophytic, coliformes, and E. coli collected during the low tide on April 9 were influenced by the high rainfalls in the previous days to this study.

In the culture of bacteria in saline water can develop halophilic and halotolerant bacteria. According to

DISCUSSION AND CONCLUSIONS

The first component of the First Component Analysis (Figure 2) explained 31.58% of the variability and demonstrated positive correlation between the salinity, dissolved oxygen, tide and, in a lesser scale the pH and temperature for the hours 03:00pm, 04:00pm, and 05:00am. On April 10, 2001 the highest values of precipitation were recorded at 03:00am which also had an influenced in the formation of the second component.

An analysis of the PCA results (Figure 2) revealed that the first component explained 31.58% of the variability, while the second component explained 23.64%.

Figure 1. Map of the studied area (JOUKOSKI et al., 2003).

Figure 2. Graphic representation of components I and II of the Principal Component Analysis highlighting the tides and hours. Temp: Temperature; Salin: Salinity; pH: Hydrogenionic potential; DO: Dissolved oxygen; Precip: Precipitation; TH: Total heterotrophic bacteria; BB: Bacterial biomass; HS: Heterotrophic halophilic bacteria; HD: Heterotrophic halopritic bacteria; TC: Total coliforms; FC: Escherichia coli.
RHEINHEIMER (1985), the halotolerant bacteria can be found in all continental waters (mainly in bays and estuaries), but in larger abundance in residual waters of cities, rivers and lakes with high contamination. Accordingly a large quantity of the cultivable ‘halophytic’ bacteria found during the low tide on April 9 should be halotolerant. High rainfalls can increase the speed of outflow of the tidal creek and also carry the stream bed deriving organic substance of the edges and the adjacent mangroves benefiting the development of culturing bacteria.

Similar results had been observed by KOLM and ABSHER (1995) in surface waters of the Paranaguá and Antonina Bays, and by KOLM and ANDRETTA (2003) for surface waters of the Perequê tidal creek. As already observed by KOLM and ANDRETTA (2003), it was also not possible to demonstrate the correlation between the rainfall and the increase of total heterotrophic bacteria.

These results confirm the description made by HOPPE (1986) that the values of culturing aerobic heterotrophic bacteria respond faster to the ambient variations and organic pollution than the values of total heterotrophs. KOLM et al. (2002) had found high values of total coliforms and few E. coli in collected superficial waters from the inner of the Antonina Bay. As many species of total coliforms occur naturally in the environment the authors believe that many of them can be autochtones in the region. As the Perequê tidal creek is rich in both particulate and dissolved organic material (KOLM and ANDRETTA, 2003), also indicates that a large part of the total coliforms occur naturally in the region.

Although analysis of total coliforms and E. coli were not done with the intention of verifying health waters standards the results indicate that during the study period values of E. coli exceeded the maximum allowed under Resolution 274 of the CONAMA (National Advice of Environment) 2000. It was also found that in accordance to the Resolution no. 20, Art. 8º of the CONAMA the region of study was not appropriate for the creation and/or the consumption of organisms to be consumed raw.

The results obtained in the present research demonstrate that in the period and region studied the tides, principally after a period of intense rain accompanied by southern winds, influenced the amount of cultivable aerobic heterotrophic bacteria, total coliforms, and E. coli. In contrast the amount of total heterotrophic bacteria had risen more during the nocturnal high tide on April 10, a period could no longer observe the influence of the cold front that had preceeded the study.

LITERATURE CITED


