

Monitoring and spatial distribution of heterotrophic bacteria and fecal coliforms in the Rodrigo de Freitas Lagoon, Rio de Janeiro, Brazil

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ABSTRACT

The distribution of heterotrophic bacteria and fecal coliforms was monitored at four sampling stations located near the shore of the Rodrigo de Freitas Lagoon, in the city of Rio de Janeiro, Brazil. Water samples were collected, monthly from October 1994 through September 1998. The highest heterotrophic count (6.5×10^7 CFU/100mL) was recorded at stations 2 and 4 during August 1998 and the lowest (10^3 CFU/100 mL) at station 3 during February 1995. With respect to fecal coliforms, the highest and lowest counts were 1.6×10^5 coliforms/100mL at station 3 during March 1997 and <1 coliform/100mL at all the stations during February 1995 and September 1997 as well as station 3 during February 1998. The data indicated a percentage increase of the microorganisms surveyed over time at all the sampling stations studied.

Key words: Fecal coliforms, Heterotrophic bacteria, Rodrigo de Freitas Lagoon, Monitoring

INTRODUCTION

The Rodrigo de Freitas lagoon lies within a densely populated region of southern Rio de Janeiro. Together with the local beaches and due to its many natural attributes, it constitutes a leisure area of marked importance to the city's inhabitants - the "cariocas". It has a central role in local tourism, being visited by many people throughout the year. However, this lagoon has received organic and inorganic pollutants coming in from untreated and unauthorized domestic sewage as well as run-offs and rivers that drain the region. Consequently, it has turned into a site with sludge outcrops in some of its margins, turbid

waters and accelerated eutrophication, with episodes of high fish mortality and bad smell. Unfortunately, it runs the risk of becoming a public health hazard (Coelho & Fonseca, 1980, 1981). According to Sales-Andrade (1973), the significant increase in organic and inorganic wastes was due to inadequate city planning of the lagoons' surrounding land and to its role as a natural settling basin. The fills of anthropic origin have reduced the natural water table and changed the course of its water circulation (Oliveira, 1955; Pires, 1977; Brito & Lemos, 1982).

At present, the lagoon is used as a water sports site, where people use paddle boats and practice mostly rowing, sailing and skiing. Competitions also take place. Many local inhabitants still go

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fishing as a means of survival (Andreata & Frederick, 1999).

In Brazil, classification of water bodies as well as the establishment of thresholds and standards for total and fecal coliforms are set by the Resolution n° 20-06/18/1986 of the National Council for Environmental Issues - Conselho Nacional do Meio Ambiente: CONAMA (1992). The Rodrigo de Freitas lagoon was ranked as brackish, with a salinity equal or below to 0.5 and 30. If adequately surveyed and quality controlled, it could be exploited as a site not only for water sports but also for bathing, protection of aquatic communities, natural and/or intensive breeding of species destined for human consumption, commercial navigation, or simply as a harmonious element of landscape.

Fecal coliforms can be exemplified by the species *Escherichia coli*, which is presently used as an indicator of sanitary conditions. It was selected because of its exclusively fecal origin and low survival time in marine or chlorinated waters, thus acting as an indicator of recent contamination of aquatic environments. According to Hagler & Hagler (1988), marine water is toxic to most enteric bacteria. In fact, 90% of an *E. coli* population tends to be eliminated within hours in a marine environment. Since this microorganism is a typical component of the fecal microflora, its detection may indicate the potential occurrence of other microorganisms which could be even more pathogenic to man and both domestic and wild animals. Water quality directly reflects the kinds of microorganisms present. Pagnocca et al. (1991) showed that the bacterial populations recovered from the guts of several aquatic animals were affected by the degree of pollution of the waters they were sampled from.

In order to contribute to a better management and suitability of the Rodrigo de Freitas lagoon, the aim of the present work was to study the spatial distribution and temporal variability of heterotrophic bacteria and fecal coliforms in its surface waters at four near-shore sampling stations, over a period of four years.

STUDY AREA

The Rodrigo de Freitas lagoon is located within the city of Rio de Janeiro (22°57'02''S; 043°11'09''W). It has an irregular, polygonal shape, a surface area of 2.5 Km² (Barroso, 1989), a perimeter of around 7.5 Km, and its largest length

runs for 3 Km (Oliveira, 1976). Maximum depth reaches 11 m (Andreata et al., 1997). The lagoon is connected to the sea essentially by the Jardim de Alah channel, which is flanked by the Ipanema and Leblon districts. The channel is 835 meters in length and is frequently blocked by silt and alluvial deposits. Being a semi-confined environment, the lagoon's water renewal and assimilation of foreign substances is complex (Miranda, 1984). Sea water inflow is smooth and very superficial, not affecting the deeper layers (Torres, 1976, 1990). The catchment basin comprises the Macacos' River as main contributor of fresh water as well as the Cabeça and Rainha Rivers (Andreata et al., 1998).

MATERIALS AND METHODS

Samples were taken from the water surface monthly during October 1994 through September 1998 at four distinct points located as shown in Figure 1. All the water samples obtained near the shore at a depth of 15 cm were collected into sterile 250mL flasks and processed for bacteriological analysis at the Bacteriology Laboratory of the Research Company for Mineral Resources (CPRM).

Heterotrophic bacteria were enumerated by counting the number of colony forming units (CFU) in Petri dishes containing plate count agar medium (Merck), after incubation at 36 ± 1 °C for 24-48 h. Fecal coliforms were enumerated by the method of the most probable number (MPN) as recommended by the American Public Health Association (APHA, 1992). Laurylsulfate broth medium (Merck) was used in the presumptive step and E.C. broth medium (Merck) in the confirmatory. In the latter case, incubation was carried out at 44.5 °C for 24h. The means and standard deviations were calculated for all the years and sampling stations.

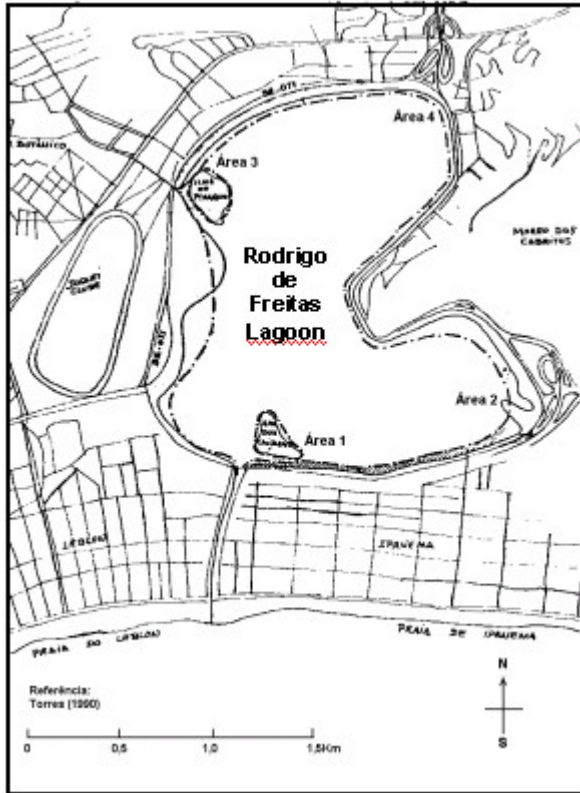


Figure 1 - Sampling Stations at Rodrigo de Freitas Lagoon (from Torres, 1990).

RESULTS AND DISCUSSION

Bacterial numbers increased gradually throughout the 4-year study period. A comparison of monthly averages per sampling station per year between heterotroph and fecal coliform counts is presented in Figures 2 to 5. Heterotrophic bacteria reached a maximum of 6.5×10^7 CFU/100mL at stations 2 and 4 during August 1998 (Figures 5b and 5d) and a minimum of 10^3 CFU/100mL at station 3 during February 1995 (Figure 2c). With respect to fecal coliforms, the highest and lowest counts recorded were 1.6×10^5 coliforms/100mL at station 3 during March 1997 (Figure 4c); and <1 coliform/100mL in all the stations during February 1995 and

September 1997 (Figures 2a-d and 4a-d) as well as station 3 during February 1998 (Figure 5c) respectively. Fluctuations in heterotrophs not always paralleled those of fecal coliform, due to the microbiological diversity of the lagoon. According to Kolm et al., (1997), even when the heterotrophs make up just a small part of total bacteria, their monitoring is of great importance, since an increase in the number of these species indicates environmental organic pollution. In the Rodrigo de Freitas lagoon, episodes of eventual or accidental pollution are becoming more frequent. Following the microbiological standards set by the National Council for Environmental Issues (Conselho Nacional do Meio Ambiente: CONAMA; 1992), the waters of the Rodrigo de Freitas lagoon were ranked as unfit for natural and/or intensive breeding of animal species, for which the fecal coliform index has to be lower than 14 bacteria per 100mL of water. Although, on occasions, our recorded numbers were below the accepted threshold limit, in the long run, fecal coliform counts were essentially higher than such value in all the sampling stations, hence demonstrating, in our opinion, that the waterbody of the lagoon should not be used as a water sports and leisure site.

Figure 6(a-b) shows the annual means of the microorganisms investigated for all the sampling stations. As can be observed, the lowest averages of both heterotrophs and fecal coliforms were found during the first year of the survey. Maximum heterotroph values were detected during the fourth year (October 97-September 98) in all the stations, implying an accretion of organic matter that is associated with the rise in heterotroph numbers over time.

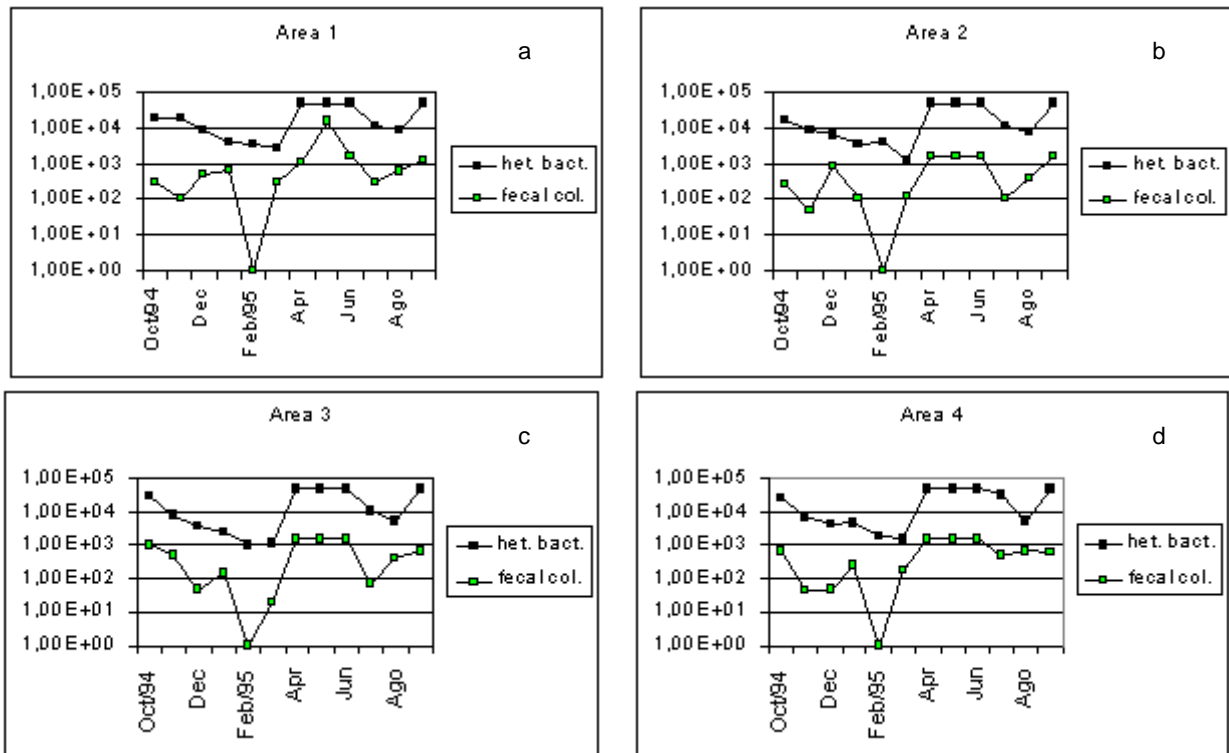


Figure 2(a-d) - Monthly distribution of heterotrophic bacteria (CFU/mL) and fecal coliforms (cells/100mL) at four sampling stations of the Rodrigo de Freitas Lagoon during October 1994-September 1995 (Log (x + 1)).

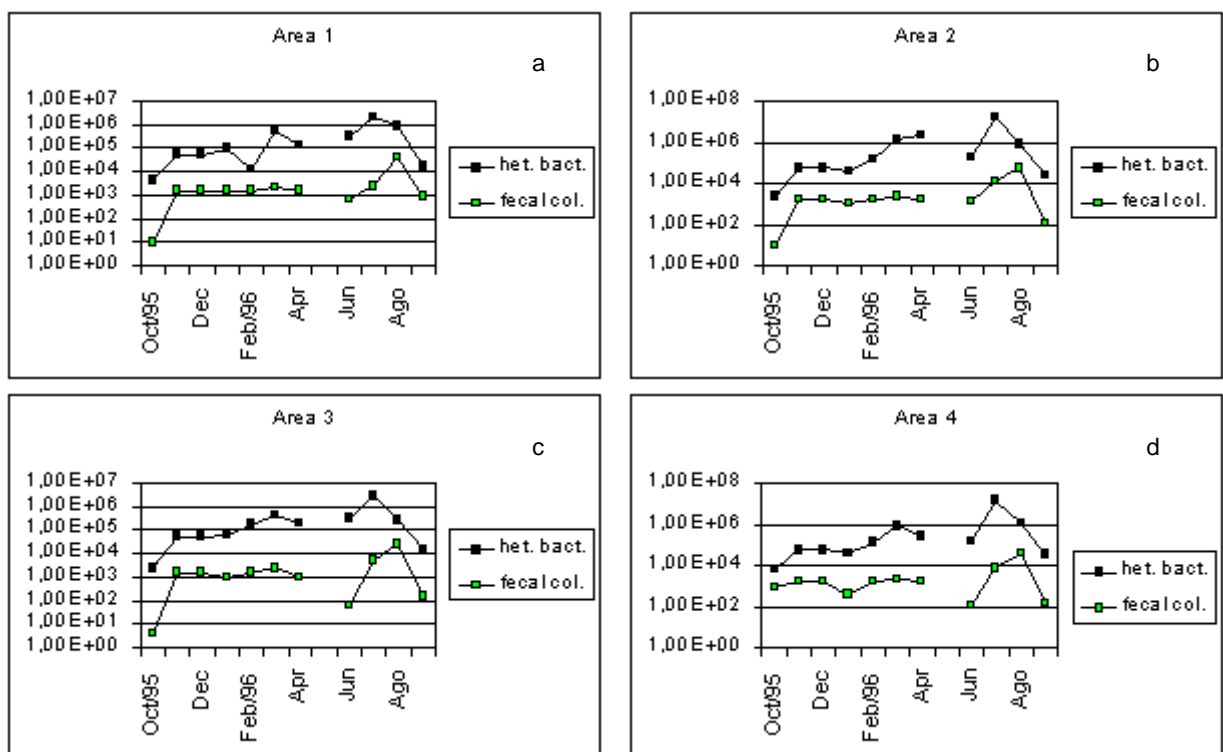


Figure 3(a-d) - Monthly distribution of heterotrophic bacteria (CFU/mL) and fecal coliforms (cells/100mL) at four sampling stations of the Rodrigo de Freitas Lagoon during October 1995-September 1996 (Log (x + 1)).

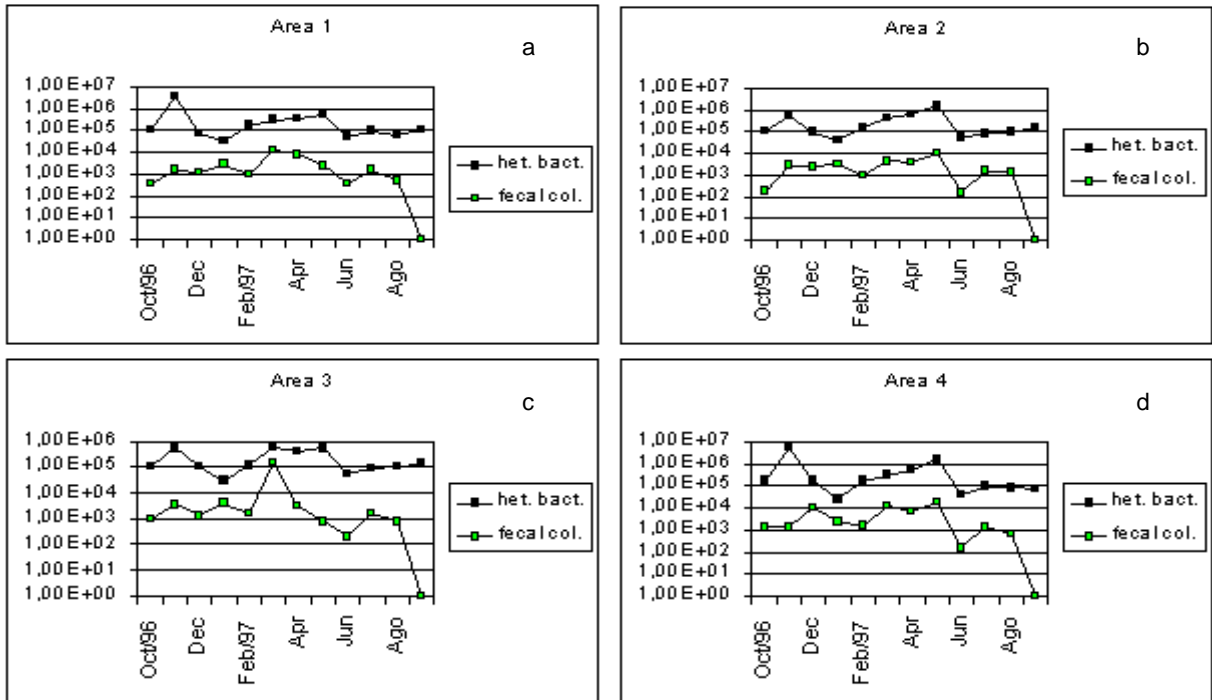


Figure 4(a-d) - Monthly distribution of heterotrophic bacteria (CFU/mL) and fecal coliforms (cells/100mL) at four sampling stations of the Rodrigo de Freitas Lagoon during October 1996-September 1997 (Log (x + 1)).

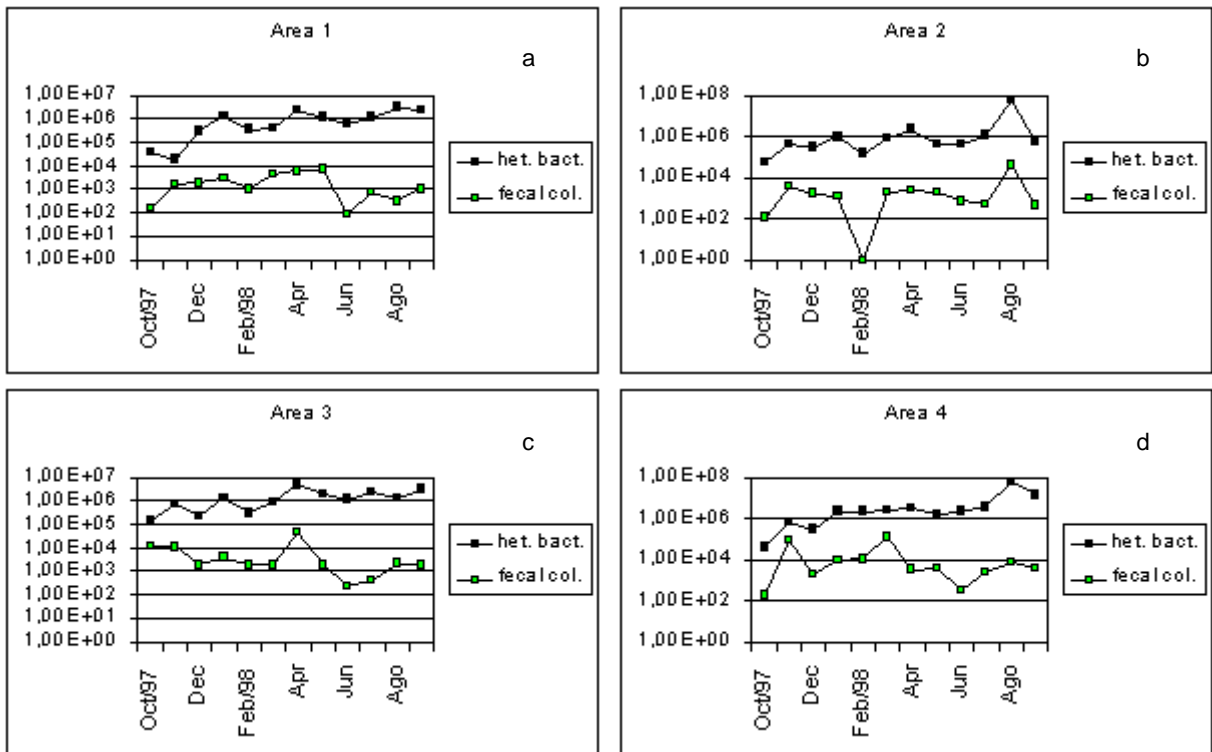


Figure 5(a-d) - Monthly distribution of heterotrophic bacteria (CFU/mL) and fecal coliforms (cells/100mL) at four sampling stations of the Rodrigo de Freitas Lagoon during October 1997-September 1998 (Log (x + 1)).

years	Heterotrophic bacteria				Fecal coliforms			
	station 1	station 2	station 3	station 4	station 1	station 2	station 3	station 4
94/95	228	216	217	234	612	686	600	650
95/96	3404	16204	3312	12927	4896	7197	3502	4869
96/97	4475	3087	2364	7099	2494	2539	14834	4528
97/98	10719	60479	14992	80817	2281	4483	7437	22385
St. Dev.	4395,22	27871,2	6641,08	37393,2	1763,86	2785,04	6166,94	9708,35

Figure 6(a-b) - Annual average counts and standard deviations of (a) heterotrophic bacteria (CFU/100mL) and (b) fecal coliforms (cells/100mL) at the four sampling stations over the four year study period.

Fecal coliforms also increased yet in an irregular manner. Stations 1 and 2, for example, showed a slight peak during October 1995-September 96 with respect to the previous year, but the two subsequent annual averages did not differ much from this maximum. Station 3 was the only site at which the highest fecal coliform mean count was recorded, during October 96-September 97. At station 4, the increase in fecal coliforms followed closely that observed for heterotrophs throughout the whole period of investigation. Although fecal coliform concentrations built up over the four year study in all the station, the highest index was found at station 4.

According to Andreatta et al. (1999), a reduction in salinity has been occurring in the Rodrigo de Freitas lagoon during the last few years, which may have led to an increase in the number of anthropogenic species, since these survive longer under lower salinity conditions. This probably relates to the specific location of each sampling station. Station 1 lies close to the Caiçaras' Island, near the mouth of the Jardim de Alah channel which connects the lagoon to the sea, and has a greater renewal of water. Station 2 lies in the southeast region, close to the connecting channel, where storm sewers are present and discharge sewage into the surroundings. Station 3, next to the Piraquê Island, occupies a northeast position not as close to the connecting channel as stations 1 and 2, and receives discharges of organic matter from the Macacos' Rives as well as the recirculation channel of the Jóquei Club, which probably contribute to the expansion of the bacterial microflora in this area. Station 4 lies furthest away from the connecting channel and the borders of the lagoon, and receives untreated and unauthorized domestic sewage.

The recurrence of high fish mortality in this lagoon has been known for many years (Oliveira, et al., 1957; Andreatta and Frederick, 1997). Apparently, microbial variability is not affected by this phenomenon and vice-versa. We observed this, for example, during July, October and

December 1995, August 1996 and February 1998. From April till June 1995, we recorded the highest heterotroph and fecal coliform counts for the October 1994 through September 1995 period (Figure 2a-d); the lowest values were detected in October 1995 for practically all the microorganisms (Figure 3a-d).

Our data indicated, in a quantitative manner, that the lagoon's organic content coming from various discharges was increasing, a fact that won't restrict more and more its use and has serious public health implications. It should also be mentioned that the outflow of the lagoon's waters into the seashore close to the Leblon district, through the Jardim the Alah channel, periodically discharges a high load of bacteria into the Leblon beach (Cravo & Lutterbach, 1997), which, as a consequence, becomes unfit for bathing over long periods of time.

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RESUMO

O monitoramento e a distribuição espacial de bactérias heterotróficas e coliformes fecais foram realizados em quatro áreas marginais da Laguna Rodrigo de Freitas, Rio de Janeiro. Amostras mensais foram coletadas no período de outubro de 1994 a setembro de 1998. A maior quantidade de bactérias heterotróficas foi de 6.5×10^7

UFC/100mL nas áreas 2 e 4 no mês de agosto de 1998, enquanto o menor valor encontrado foi de 10^3 UFC/100mL na área 3 em fevereiro de 1995. Quanto aos coliformes fecais os maiores valores foram de 1.6×10^5 colif./100mL na área 3 em março de 1997 e os menores valores encontrados foram < 1 colif./100mL em fevereiro de 1995 e setembro de 1997 para todas as áreas, e fevereiro de 1998 para a área 3. Foi verificado um aumento ao longo do tempo dos percentuais de microrganismos nas áreas estudadas.

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