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# Patos Lagoon: Indicators of Organic Pollution

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**ABSTRACT**

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Patos Lagoon is the largest receptor of fluvial waters used for agricultural, navigational and fishing activities in the state of Rio Grande do Sul. The dumping of industrial and domestic effluents into those waters is its worst polluting source. Aiming at assessing organic contamination, 16 points were sampled along the lagoon (winter and summer). Ammonium and BOD rates (chemoindicators of organic contamination) increased in summer in waters to the south of the lagoon adjacent to the cities of Rio Grande and São Lourenço and, more to the north, near Camaquã river. In the winter, the waters near the cities of São Lourenço and Tapes (located to the north of the lagoon) also presented increases in those parameters rates. Fecal coliform bacteria rates presented a similar pattern to that of chemical parameters, increasing in waters near the cities of Rio Grande and Pelotas (São Gonçalo Canal and Laranjal beach), both situated to the south of the lagoon. No contamination was verified in channel areas along the lagoon's axis, due to stronger hydrodynamics and the distance from urban contamination sources. An intrusion of saline water into the estuarine water at the south of the lagoon occurred in the winter. A marked stratification was defined in the water column, with oxygen subsaturation in bottom waters, due to resuspension of deposited sediment and release of semi-anoxic interstitial water. Although Patos lagoon is a national heritage of touristic, ecologic and economic importance, it has been degraded by effluents, urging their treatment and hydro-sanitary monitoring.

**ADDITIONAL INDEX WORDS:** *Domestic effluents, coliforms, BOD, Patos Lagoon.*

## INTRODUCTION

Patos Lagoon is the main receptor of fluvial waters on the Rio Grande do Sul state coastal plain, with a catchment basin of 200,000 Km² and volume of 60 million cubic meters. Features emphasized are the Guaíba river, the Camaquã river, the São Lourenço do Sul river (up north) and the São Gonçalo Canal (down south, joining both Patos and Mirim lagoons). At the mouth of Patos Lagoon by the Atlantic Ocean an estuary is formed, representing about one tenth of the lagoon (Fig. 1).

The waters of such hydric environment benefit populations settled on their shores. Of noticeable importance, up north is the state capital (pop. 1,359,932), to the center are the cities of Tapes (pop. 16,282) and Camaquã (pop. 60,369) and to the south are São Lourenço (pop. 43,698), Pelotas (pop. 323,034 ), Rio Grande (pop. 200,000) and São José do Norte (pop. 23,792).

Those waters are also used for irrigating shore croplands, commercial and touristic navigation as well as fishing, particularly at the estuarine portion, where the cities' economy is very much directed to such activity.

Besides the intense importance of this lagoon, several polluting sources do exist in the region. It is noticeable the lixiviation of agricultural land, especially where there is deforestation on the margins, and atmospheric precipitation originating from industrial centers, as well as emissions from port centers, basically concentrated to the north and south ends of the lagoon. Greater importance is attributed to the dumping of untreated domestic urban effluents, as there is a lack of sewage treatment and basic sanitation in most cities located on the shores.

Information on the chemical quality of the waters of Patos lagoon are generally scarce. Previous studies (NIENCHESKI *et al.*, 1988; VILAS BOAS,1990*)* showed that the Guaíba river (receptor of effluents from the Porto Alegre area), and the estuary of Patos Lagoon (receptor of untreated effluents from Rio Grande, Pelotas, and São José do Norte) have presented signs of eutrophication.

The present study assesses organic contamination in the waters along the lagoon, simultaneously considering margin and channel areas. Such sampling strategy is inedited for the region, particularly because, along with hydrochemical parameters, the levels of total and fecal coliform bacteria were analyzed for the first time.

## METHODS

Sixteen points distributed along the lagoon were sampled. Points numbered 0 through 7 were positioned in channel areas along its central axis, where surface and bottom samples were collected using the Larus Oceanographic Vessel and an aluminium boat.

Points numbered 8 through 16 were located at marginal areas of the lagoon, at strategic spots in terms of a possible presence of urban effluent dumping. At those spots, only surface samplings were performed, due to the relative lesser depth than that found in channel waters (Fig. 1). Sampling periodicity was winter and summer (August and December/2001).

Temperature and salinity were measured aboard the vessel with a portable thermometer and salinometer. Suspended matter was determined by gravimetry. Dissolved nutrients (ammonium, nitrite, nitrate, phosphate) were analyzed after sample filtration through 0.45μm-pore filter (BAUMGARTEN *et al.*, 1996). Oxygen was determined based on Winkler's reaction (BAUMGARTEN *et al*., 1996). Biochemical Oxygen Demand ($BOD_5$), and total and fecal coliforms were analyzed according to method described in APHA (APHA, 1992).

## RESULTS AND DISCUSSION

Temperature variation between the winter and the summer followed a seasonal pattern. In terms of salinity, saline water was only present to the south of the estuary. In the winter, stratification was verified, with intense fresh water flushing on the surface of the channel towards the ocean and influx of coastal water through the bottom, invading areas around the city of Rio Grande. In the summer, the estuary was fully dominated by brackish waters, without any stratification.

The water along the whole of the lagoon, particularly on the

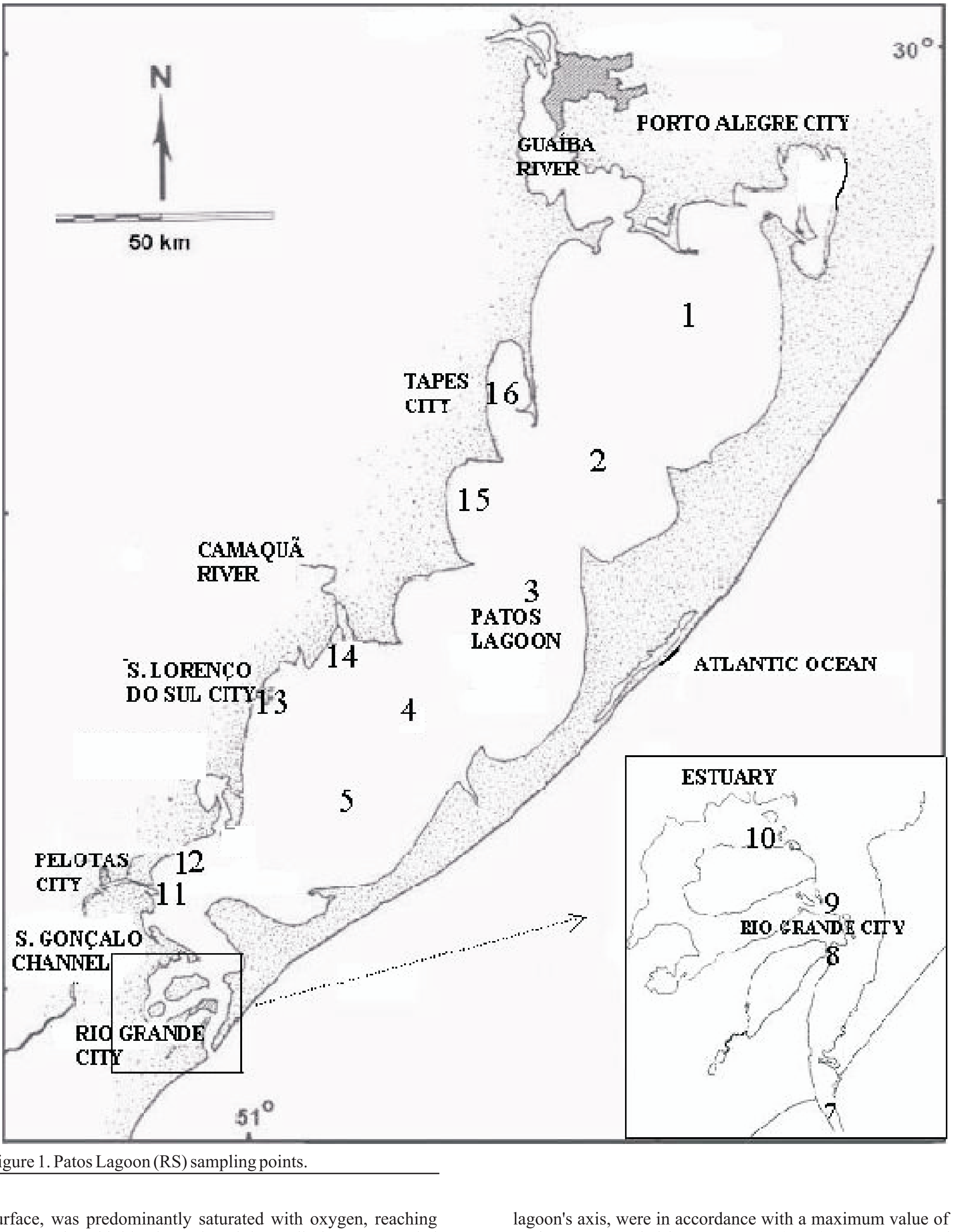


Figure 1. Patos Lagoon (RS) sampling points.

surface, was predominantly saturated with oxygen, reaching concentrations highly above the minimum limit recommended by CONAMA (1986) for fresh waters Class 1 (>6mg/L), as well as brackish ones Class 7 (>5mg/L). Still, particularly in the winter, subsaturations (around 85%) were verified in bottom waters in the estuary. As this fact coincided with important increases in concentrations of suspended matter and salinity, the influx of saline water into the estuary may have possibly resuspended deposited sediments and released oxygen-poorer interstitial water.

In spite of intense effluent influxes by the shores of the lagoon, most BOD results, mainly in channel areas on the lagoon's axis, were in accordance with a maximum value of 5 mg/L recommended by CONAMA (1986). However, results obtained in the summer at places near the cities of Camaquã, São Lourenço (north of the lagoon) and particularly in waters near the city of Rio Grande, within the port estuarine area (points 14, 13 and 9, respectively) (Table 1) were exceeding, indicating contamination of such waters by biodegradable organic matter of anthropic origin, by clandestine domestic effluents and, in the case of Rio Grande, by effluent from the fishing terminal located near the sampling point.

Other than BOD, dissolved ammonium is also an important chemoindicator parameter for water contamination by

Table 1. *Concentrations of studied parameters from stations sampled during the winter (w) and summer (s), compared to reference values: * CONAMA,1986 and **DMAE,1979.*

| Parameters | Pelotas city | | | | Rio Grande city | | S.Lourenço river | | Camaquã river | | Tapes beach | | References |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S. Gonçalo Channel (point 11) | | Laranjal beach (point 12) | | (point 9) | | (point 13) | | (point 14) | | (point 16) | | |
| | w | s | w | s | w | s | w | s | w | s | w | s | |
| **BOD mg/L** | 2.6 | 2.6 | 2.3 | 3.2 | 4.53 | 6.03 | 0.88 | 6.77 | 2.52 | 5.74 | 2.64 | 3.5 | 5* |
| **Ammonium mg/L N** | 0.03 | 0.21 | 0.03 | 0.34 | 0.03 | 0.61 | 0.03 | 0.21 | 0.03 | 0.35 | 0.05 | 0.19 | 0.1** |
| **Phosphate mg/L P** | 0.07 | 0.02 | 0.02 | 0.02 | 0.11 | 0.03 | 0.02 | 0.02 | 0.03 | 0.01 | 0.02 | 0.03 | 0.025* |
| **Total Coliforms (.$10^3$)NMP/100ml** | 160 | 23 | 16 | 23 | 160 | 23 | 16 | 1.1 | 1.3 | 1.7 | 16 | 3 | 5* |
| **Fecal Coliforms (.$10^3$) NMP/100ml** | 8 | 1.6 | 0.7 | 23 | 30 | 23 | 1.3 | 0.11 | 0.5 | 0.04 | 9 | 0.23 | 1* |

untreated domestic effluents, which are rich in this nutrient, due to their high concentration of organic matter. Upon decay, a significant concentration of ammonium (ammonification) is generated.

Ammonium contamination was noticeable at places near urban centers on the lagoon's shore, where rates exceeded the value of 0.1 mg./L (5μM), considered to be normal for unpolluted coastal environments (CONAMA, 2000). The area near the fishing terminal in Rio Grande must also be singled out, as the same was verified regarding BOD values found in this place.

Ammonium increases were sharper in the summer (Table 1), as the temperature increase favors organic matter-decomposing bacteria metabolism, especially where there is a lot of anthropic influx. Also in the summer, there was a lower oxygen saturation, which favored the permanence of ammonium in the water column, as the ammonium oxidative processes (nitrification) were disfavored. In support of such hypothesis is the finding that during the summer, nitrate (ion resulting from the total oxidation of ammonium) rates were very low at ammonium-rich places.

Regarding phosphate, the pattern of seasonal variation was not the same verified for ammonium, indicating a different origin for this nutrient. It was verified that, in the summer, the results oscillated around the maximum limit recommended by CONAMA (1986), that is, 0.025mg/L (0.8μM). However, in the winter, its rates increased in points situated to the north of the lagoon, towards the cities of Porto Alegre and Camaquã river and especially Rio Grande, in the surroundings of the fishing terminal (Table 1). Such punctual increases in phosphate suggested an industrial emission origin for this nutrient into the water. Particularly in Rio Grande, in certain hydric areas, phosphate contamination has already been verified to come from fertilizer industries at the Industrial District located on the city shores (BAUMGARTEN *et al*., 1995), which mainly operate during winter and spring periods. Additionally in winter, the increase in wind and rain intensity carry phosphatic dust released by such factories to the waters around the city in a more intense fashion.

As for coliforms, these bacteria receive a special emphasis from the environmental legislation ruling water quality for bathing (CONAMA,1986; CONAMA, 2000) and the sanitary quality of a given aquatic environment. Included in total coliforms levels are the fecal coliforms, which are primary indicators of contamination by fecal residues, as they are specific to the intestinal tract of homeothermic animals. Although, such bacteria do not usually cause the diseases themselves, their presence in the water indicates that it receives untreated, fecal waste-rich domestic sewage, with an intense potential that other morbidity-provoking microorganisms might also be present in the receiving water.

In the channel waters on the lagoon's axis, as for the other parameters analyzed, no contamination by fecal coliforms was identified, as a consequence of the strong water circulation, which does not favor bacteria proliferation. In those waters, the highest level, 230 nmp/100ml, was about five times lower than the maximum limit recommended for fresh and brackish waters (CONAMA,1986). It is also within the maximum limit recommended for waters with acceptable quality for bathing, even though it is highly strict (CONAMA, 2000).

However, near the shores, the contamination by such bacteria was significant, emphasizing again the waters near the shores of the city of Rio Grande, in the surroundings of the fishing terminal (point 9), where the levels of fecal coliforms always oscillated between 30,000nmp/100mL (winter) and 23,000nmp/100mL (summer) (Table 1). Although the priority use for such waters if not bathing, this is a worrisome fact, as contamination was generalized for every indicator parameter of organic contamination and those waters are highly used for navigation and small-scale fishing, and surround the central portion of the city.

Coliform contamination was also highly intense at points 11 and 12 (the region of Pelotas city, particularly the São Gonçalo Canal and Laranjal beach). In the summer, at the referred beach, levels reached an alarming extreme of 23,000 nmp/100ml, certainly due to the increase in local population during the period, generating sewage, which is discharged without any treatment towards the beach. Beach contamination had disappeared in the winter, but it was sustained in the canal, due to untreated domestic effluent influxes.

In the winter, coliform contamination was also found in the waters of the São Lourenço river (point 13) and Tapes beach (point 16). That was a consequence of the increase in pluviometric levels during the period, accentuating lixiviation of solid and fecal waste originated from the large number of precarious housing on the shores of those hydric environs that run into the lagoon.

## CONCLUSIONS

In spite of Patos Lagoon being a national heritage of extreme touristic, ecologic and subsistence importance for the small-scale fishermen and agricultural irrigation, it is being degraded in some of its shore areas, generating processes of punctual eutrofication.

In the winter, this problem was accentuated by the increase in the pluviometric level, causing more lixiviation of urban areas lacking basic sanitation. In the summer, the increase in population density in lagoon balnearies also lacking basic sanitation, such as Pelotas (Laranjal beach), has resulted in an intense increase in organic contamination to the marginal waters of the lagoon.

Those factors have altogether generated a seasonal variation pattern of organic contamination, which is specific for each sampled area.

In waters along the lagoon's axis, the stronger hydrodynamics and greater depth increased their self-depuration potential. No organic matter contamination was found in those waters.

However, as the marginal waters are more directly used by the population for direct or indirect contacts, it urges the installation or fitting of sewage treatment plants in the cities located on the shores of the lagoon. Also, the various programs of water sanitary quality monitoring that have been initiated in the lagoon and suspended due to lack of funds must be implemented continuously in space and time, so that it may be defined if the contamination is ascending or descending. Monitoring of areas that were not sampled in the present study, such as the shores of Porto Alegre city and Saco da Mangueira bay, in Rio Grande city must also be included, because both are receiving untreated domestic urban effluents.

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