# APPLICATION OF ORBITAL REMOTE SENSING TECHNIQUES IN STUDYING THE WATER QUALITY IN LAGOA DA CONCEIÇÃO, SANTA CATARINA ISLAND - BRAZIL

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**ABSTRACT**

By utilizing environmental data (physical, chemical and biological ones) sampled in the years of 1988/89 in the Lagoa da Conceição as well as the same period TM Landsat 5 satellite images statistical correlations were established. Owned to the non-coincidence between the sampling days and the satellite passage mean punctual values and the satellite passing day weather conditions similar values were used. Among all the selected environmental data, a water quality indicating bacteriological parametar was used. The results suggest that a set of more studies concerning to that variable should be carried out.

## Introduction

The anthropic action has a large share on the impact changing which can be seen on coastal environments. These ones are distinguished by a high biological productivity and for geomorphological processes as well as water dynamics and quality characteristics deeply defined HARTMANN *et al.* (1990).

Led by the need of coming to know and preserve such ecossystems, several researchess have developed their works within that environment. As part of the coastal zones the coastal lagoons have been used as "test-area" for the development of such projects, including the application of remote sensing techniques on its studies. According to HARTMANN of Sano (1986) the remote sensing techniques are real "tool" on aquatic environment studies due to multiespectral, multitemporal and synoptical data attainment.

Several biological, geological, sedimentological, sanitary data as well as many others studies have already been developed in the area chosen for the present work, that is to say, the waters of the Lagoa da Conceição. Studyng in the lagoon's water quality, RODRIGUES (1990) determined bacteriological, physical and chemical parameters by utilizing 1988/1989 water samples. These data served as basis to establish the aine of this work that's to say, to correlate environmental parameters with the TM Landsat 5 satellite multispectral data.

## Area Under Study

The area is located on the island of Santa Catarina, in Florianópolis city, between the latitudes 27°30' 37 and 27°37 32' S and the longitudes 48°25'16 and 48°29'03'W. It covers an area of approximately 20 square kilometers, although it is considered a small system. The maintenanie of high quality rates of its waters is fundamental not only as a natural resource but also as a fishing, tourism, sports and trade activity source shared by several social segments in the region (SIERRA DE LEDO, B. *et al.*, 1982).

## Methodology

The equipment and materials used for the present study were:

1. SITIM-150 (Images Treatment System)
2. SGI (Geographical Infortation System)
3. Digital product corresponding to LAMSAT 5TM Satellite, WRS 220.79/E, concerning March, 27, 88, stored in CCT tapes
4. Cartographic products (IBGE - topographic letter, Statistics and Geography Brasilian Institute) scale 1/50.000 and water sample map of Lagoa da Conceição made by RODRIGUES (1990).

## Environmental Data Selection

The environment data of bacteriological, chemical and physical parameters (pH, salinity, water temperature, Secchi depth total, coliforms) corresponding to 1988/89 were taken from the work of RODRIGUES (1990).

To determine the statistical correlations between the environmental variables and orbital data water analysis results were selected, which correspond to 10 sample points out of the 13 points described by the author. The selection was based on the most representative samples found I-C, where the circulation of water masses is more intense and the depth ranges between 1 to 8 meters.

The metereological data used were: wind direction, rainfall rates, air temperature and tides obtained in the DPV (Flight Protection Departmente - Florianópolis Airport).

## Digital Processing and Orbital Image Analysis

Qualitative data were taken from digital products, by mean of visual analysis, and quantitative data by using mathematical models available at SITIM-150. TM-4, TM-3, TM-2 and TM-1 bands were chosen for this work. TM-4 isolated the area of study for the property bodies of water present for high energetic absorption in this band, what makes them darker and possible to delineate them.

TM-3, TM-2 and TM-1 bands (the latter in special) are featured enabling light high levels to come through water bodies. Those bands were modified by removing the light excess, which is due to light scattering in the these spectral bands from this enhancement oppe-ration the stages fallowed as below:

. To determine the grey levels average values in each band (TM-3,TM-2 and TM-1) corresponding to the water sample points related to a150 m X 150 m, 5 X 5 "pixels" area (BRAGA, 1988).

. Digital filtering by applicating a low-pass filter (7 X 7 matrix) which attenuate or remove entirely those patterns in the image corresponding to spatial high frequency (MENDES, 1990).

. A high-pass filter (7 X 7 matrix) was apllicated on the same image in order to allow a better defferentiation on spectral patterns (PARADELLA, 1990).

. Creation of two newer bands from the ratio between channels by dividing the TM-1 by TM-3 and TM-1 by TM-2.

. Grey levels values determination corresponding to the water sample points on the filtered bands (TM-3, TM-2,TM-1) and on those generated by the ration operation (TM 1/3 and TM 1/2) relating to a 150 m X 150 m, 5 X 5 "pixels" area.

. The working image has been registered by using a cartographic bare the IBGE's, scall 1:50.000 mapping and the water sampling points map (RODRIGUES, 1990), scall 1:50.000. Common points on both map and image were obtained and created the mapping equations (2nd degree polynomial estimating). Control points with an accuracy lesser or equal to one "pixel" were considered.

. The chart generation algorythm available in the Geographical Information System, was used to elaborate the sampling point map as well as their latitudes and longitudes determination in order to make the image's bands grey level readings.

## Statistical Analysis

The data statistical treatment obeyed the standards as follows:

. The matrices elaborations, containing: 1) The average values of the wateranalysis results corresponding to the sampling points; 2) Water analysis mean values presenting similarity with the satellite passing day weather conditions.

. TM-3, TM-2, TM-1, TM-1/3 and TM-1/2 band's grey level average values establishing a 5 X 5 "pixels" area.

Later, the correlation analysis among all the variables was chosen, trying to achieve the association rates among those ones (Pearson Coefficient).

The $\alpha = 0.05$ assurance rate has been established as a correlation limit. The significance level established for the liberty degrees (n-1) was $\leq -0,6$ and $\geq 0,6$ (FISCHER, 1978).

## Results and Discussion

The first statistical analysis refering to the environmental data's mean values and to grey levels mean values corresponding to the working image which suffered only the pre-processing basic opperations indicated the most meaningfull correlations within the $\alpha = 0.05$ assurance interval had been the variables: water temperature on the band TM-2 (r = 0.59168); water temperature with light dispersion coeficient (r = 06683); TM-3 band with water temperature (r = 0.701404) and TM-1 band with the total coliforms rates (r = 0.854760). Others correlations rates are on the Table 01 (annexed).

The meaningful correlation presented among the orbital variables remain on the expected, if one considers that the chosen bands are in the electromagnectic specter visible light band.

The environmental data presenting similarity with the weather condictions on the satellite's passage day were too submited to the statistical tests. The values are shown on Table 02 (annexed). On this Table one may final de "r" coeficients for the treated images in SITIM-150. The best rates found are:

Total coliforms/TM-1 = - 0,88
Total coliforms/TM-3 = - 0,89
Total coliforms/TM-2 = - 0,9176
Ratio TM-1/TM-2/salinity = - 0,6170

## Conclusion

This paper demonstrates the viability of correlating multiespectral data with environmental parameters even without the coincidence with the satellite passage. The best correlation rates were obtained from the analysis of the environmental data alike the satellite passing day weather conditions.

The literature shows that, in a general way, authors agree abouth the use of multispectral sensors for estimating physical, chemical and biological parameters within aquatic bodies (TASSAN, 1987), (KHORRAN, 1981), (FROIDEFOND *et al.* 1991).

The most used parameters as in the continental waters studies as in those ones concerning to coastal environments are chlorophyll, salinity, suspended sediment and so (JENSEN *et al.* 1989), (LILLESAND, 1986), (CASELLES*et al.* 1986).

The total coliform variable, a parameter that indicates water quality, has not been registered in the checked literature as a parameter correlationable to multiespectral data.

This work tries to bring on a contribution of increasing new environmental variables to be correlationed with multiespectral data. It's expected that other studies on this theme come to test the variable viability mentioned in this paper.

**Aknowledges:**

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Msc. Ricardo ad-Vincula Veado LARS-SC

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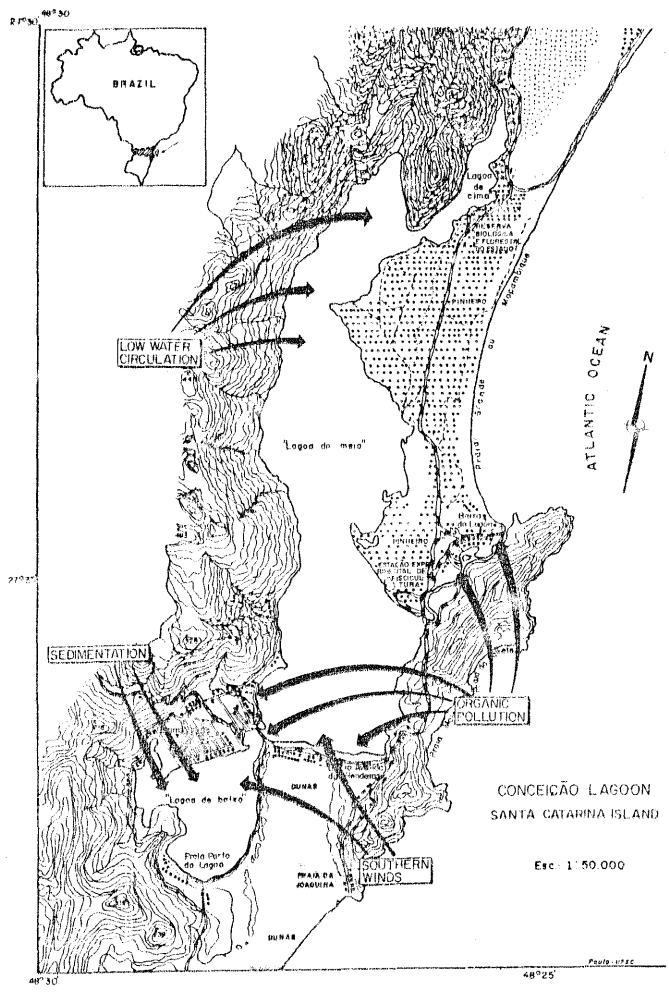
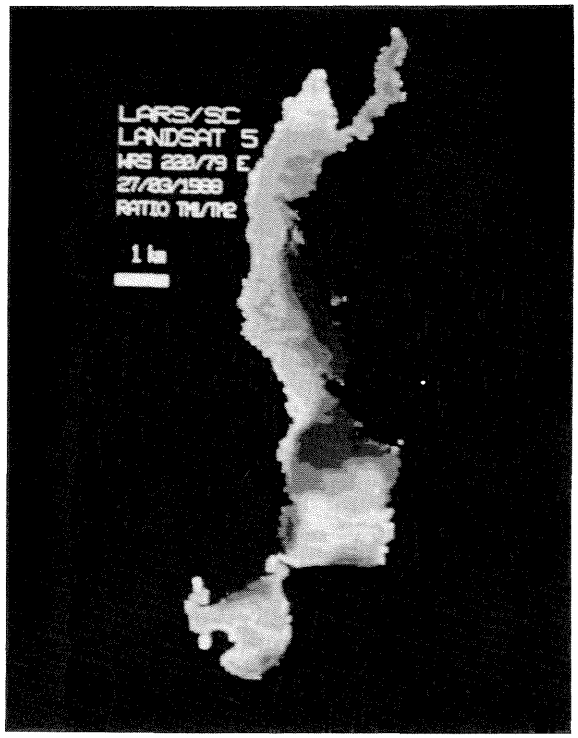
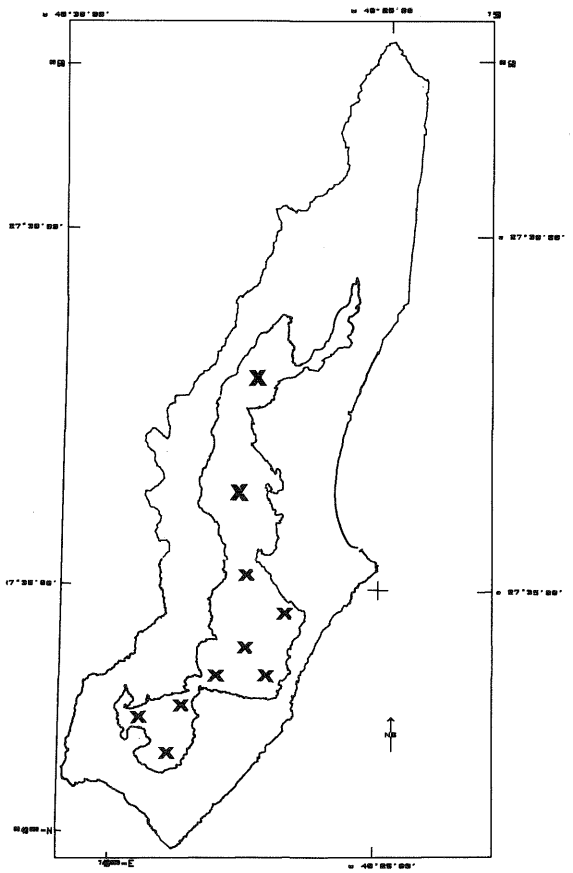



**Location area map, from SIERRA-DE-LEDO,B.(1982).**







Water sampling location in Lagoa da Conceição

table 1: Correlations levels from absolut data and processed TM bands.

| | TM1 | TM2 | TM3 | TM1/TM2 | TM1/TM3 |
|---|---|---|---|---|---|
| TM1 | 1.00 | | | | |
| TM2 | 0.90 | 1.00 | | | |
| TM3 | 0.91 | 0.98 | 1.00 | | |
| TM1/TM2 | 0.69 | -0.80 | -0.83 | 1.00 | |
| TM1/TM3 | 0.53 | -0.69 | -0.77 | 0.85 | 1.00 |
| Tot.Col. | 0.88 | -0.91 | -0.89 | -0.52 | 0.46 |
| Sal. | 0.25 | 0.38 | 0.26 | -0.37 | -0.09 |

obs: TM1 - BAND 1
TM2 - BAND 2
TM3 - BAND 3
TM1/TM2 - RATIO BAND 1 AND BAND 2
TM1/TM3 - RATIO BAND 1 AND BAND 3
Tot.Col. - Total Coliforms in 09/05/1988
Sal. - Salinity in 04/15/1988

table 2: Correlations levels from average data and non processed TM bands.

| | Tot.Col. | Temp. | pH | Sal. | Transp. | TM1 | TM2 |
|---|---|---|---|---|---|---|---|
| Tot.Col. | 1.00 | | | | | | |
| Temp. | -0.01 | 1.00 | | | | | |
| pH | 0.17 | -0.53 | 1.00 | | | | |
| Sal. | -0.51 | -0.09 | -0.11 | 1.00 | | | |
| Transp. | 0.17 | -0.60 | 0.53 | 0.29 | 1.00 | | |
| TM1 | 0.54 | -0.17 | -0.01 | -0.43 | 0.07 | 1.00 | |
| TM2 | -0.06 | 0.59 | -0.02 | 0.26 | -0.04 | 0.27 | 1.00 |
| TM3 | 0.14 | 0.71 | -0.01 | 0.08 | -0.04 | 0.45 | 0.91 |

obs: Tot.Col. - Total Coliforms
Temp. - Temperature
Sal. - Salinity
Transp. - Water Transparency
TM1 - BAND 1
TM2 - BAND 2
TM3 - BAND 3

table 3: Environmental conditions from the collected data and the LANDSAT TM overpass day:

| | wind direction | wind speed | tide | precip. rate(mm) |
|---|---|---|---|---|
| 03/27/1988 TM overpass | NORTH | 7 KNOTS | HIGH | 0.0 |
| 04/15/1988 collected data | NORTH | 8 KNOTS | HIGH | 0.0 |
| 09/05/1988 collected data | NORTH | 8 KNOTS | HIGH | 0.0 |