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USE OF HYPERSPECTRAL SENSOR WITH AN OBLIQUE VIEW TO IDENTIFY THE PRESENCE OF CHLOROPHYLL-A IN QUINTA DA BOA VISTA LAKE, RIO DE JANEIRO

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ABSTRACT

This study aims the use of mobile hyperspectral remote sensing with an oblique view to evaluate and monitor water quality. The goal is to detect if a certain water is appropriate for physical contact. The parameter used in this water assessment is the concentration of chlorophyll-a, an important indicator of plankton biomass (viruses, bacteria, fungi and protozoa).

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INTRODUCTION

Increased pollution and scarce water resources are issues of growing concern in the world. Drinking water resources are showing signs of unavoidable extinction due to the degradation of water quality. At present there is an urgent need to study and evaluate the various water resources in the world. In Brazil, the volume and diversity of inland water resources is high, which allows the use and multiple uses, increasing the need for conservation programs, management and recovery of rivers, lakes, lakes, and beaches. Inland waters in Brazil form a complex system with great potential for use (Tundisi *et al.*, 2006). In this context, the concern with water quality increases with the search for new tools to monitor this problem. The use of remote sensing in aquatic environments has contributed much in the data collection for this study (Novo, 2006). In addition to the use of data generated by orbital sensors, there is a growing use of sensors and equipment for data transmission on board aircraft, in order to study events, phenomena and processes that occur on the Earth's surface. The use of hyperspectral images, obtained simultaneously in several spectral bands, can make it possible to identify the physical characteristics of the targets, their spatial distribution and, when they have images obtained at different dates, it can allow the study of variations that have occurred over time in that region (Florenzano, 2002). Earth surface objects reflect, absorb and transmit electromagnetic radiation in portions that vary with wavelength and according to their biophysical-chemical characteristics. The variations of the energy reflected by the objects can be represented by reflectance curves, being possible to distinguish the objects of the terrestrial surface by means of these variations. The representations of the objects in these images vary from white, when they reflect a lot of energy, to black, when they reflect little energy (Florenzano, 2002). The patterns of the reflectance responses of the different types of materials are obtained by measuring the intensity of the electromagnetic radiation per reflected wavelength of the objects. These measurements are usually presented in the form of graphs called spectral reflectance curves (Jensen, 2009). The interpretation of the spectral behavior of water, compared to other natural targets, is of great difference and complexity, because the energy that water reflects is considerably less than the energy reflected by the other targets, being the most important factor in studies by hyperespectral images (Novo, 2006). In conducting a remote sensing study in aquatic environments, it is very important to understand the spectral behavior of the studied water from

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pure water, which selectively absorbs and / or reflects the incident radiation. For this, it should be considered how the incident light is affected when the water column is not pure, but contains organic and inorganic materials. Thus, the reflectance of a given aquatic system contains information on the concentration and type of optically active components in the volume of water (Jensen, 2009). In the last years, the analysis of hyperspectral images has become a mature practice, with numerous successful results and having as main applications, vegetation mapping, urban pollution characterization, evaluation of degraded areas, detection of tumors, location of targets.

The use of airborne hyperspectral remote sensors to identify spectral characteristics from the energy reflected by the body of water provides an extended and momentary perception of the spectral behavior of the entire imaged area. The comparison between the signals recorded by the sensor and the spectral behavior, measured with portable equipment, allows the identification of spectral features associated with the substances found in the water, such as: chlorophyll, suspended inorganic material and dissolved organic matter. These spectral features are dependent on the wavelength and thus influence and the magnitude of the reflected spectrum from the water (Koponen *et al*., 2002). The use of a hyperspectral sensor in soil has been described as an unprecedented experiment in the work of mapping and classification of corals (Caras *et al*., 2013), which demonstrates a current need for further investigation of the use of hyperspectral sensors in soil. Studies of water quality in water bodies are limited to spectral bands of the visible, region where the main peaks of water reflectance occur, and in the near infrared. All water bodies have suspended sediments, and the spectral response of water is directly linked to these optically active components, represented by inorganic sediments such as sand, and organic sediments such as phytoplanktonic organisms. Inorganic sediments are the major responsible for the scattering of light incident on the water, and secondly the organic sediments, more specifically the phytoplankton (Londe *et al*., 2006). Phytoplankton is a heterogeneous group composed mainly of photosynthetic algae that are distributed throughout much of the continental marine and aquatic environments (Arraut, 2005). As far as phytoplankton pigments are concerned, there is a significant variety within a body of water. Some examples of photosynthetic pigments are chlorophylls a, b, c and carotenoids. However, the main responsible for the absorption of light energy is chlorophyll.

The interpretation of reflectance and absorption spectra of water and its optically active components serve as a basis for the evaluation and monitoring of the trophic state of lentic environments using remote sensing methods. In this way it is possible to establish relations between the concentration of chlorophyll and the spectral response obtained by the hyperspectral sensor. The remote sensing technique of chlorophyll-a detection is used for water assessment and monitoring of water resources as a parameter of biomass quantification. Figure 1 shows the influence of the chlorophyll a content on the water reflectance, in addition to being able to confirm the information of Figure 1, in relation to the absorption, it is also possible to verify the reflectance peaks. It can be observed in Figure 2 that chlorophyll-a has two absorption peaks: one in the blue, approximately 433 nm, and the other in the red, around 686 nm (Londe *et al*., 2006).

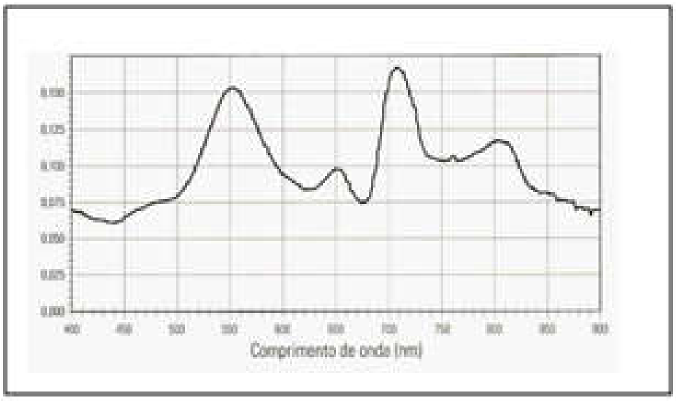

Fig. 1. Clorophyll-a Influence on water reflectânce (Kirk, 1994)

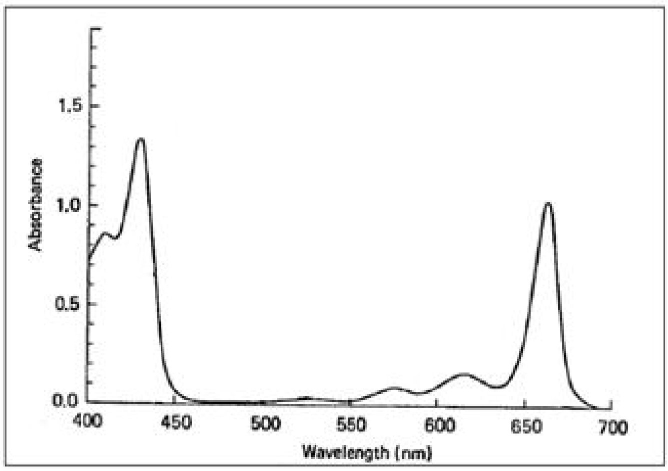

Fig. 2. Absorption spectrum of chlorophyll-a (Kirk, 1994).

MATERIALS AND METHODS

The process of image acquisition in hundreds of recorded and contiguous bands, in order to allow a complete spectral reflectance curve to be derived for each pixel, is called imaging spectrometry or hyperspectral remote sensing (hyperspectral remote sensing). The purpose of hyperspectral remote sensing is to quantitatively measure the spectral signature of the Earth system components from calibrated spectra. The use of remote sensing data has presented great potential for the identification of water quality, allowing monitoring at different spatial and temporal scales. Remote sensing made possible the evaluation of responses resulting from disturbances introduced by human activity, in order to predict the impact of these actions on their conditions of sustainability in the medium and long term. These techniques can be used efficiently to prevent, detect and monitor changes in the aquatic system. The spectral effects of optically active components on water reflectance have been widely discussed. Regarding the work (Caras, 2013), the research carried out here presents a use of differentiated sensing. The work of the cited authors uses a vertical type measurement technique, similar to those obtained by satellite, whereas the measurements carried out in this research execute measurements with the oblique view of the sensor, which will be treated in the proposed method. Therefore, it is the objective of this study to detect the presence of chlorophyll-a using the remote sensing field hyperspectral data. For this, the HandHeld2 portable spectroradiometer with wavelength range of 325 nm to 1075 nm was used. The development of the proposed research can be structured according to the following steps:

- Performing a survey of the region to be studied, which in this case study was the Quinta da Boa Vista lake;
- Planning the field work, region selected in the previous step, performing the radiometric measurements;
- Graphical evaluation of the measurements data, observing the bands with the greatest influence on the chlorophyll-a spectrum.

Area of study

For the purpose of surveying a region to be studied, the Quinta da Boa Vista lake was chosen because it showed indications of the phenomenon called eutrophication of water, that is, the excess of the presence of organic matter. Although it is a site of great beauty, the lake presents signs of contamination associated with the presence of algae and chlorophyll-a, according to Figures 3 and 4. As already mentioned, chlorophyll-a is an indicator of trophic conditions (Goodin *et al*., 1993). Another important factor for studying the water of this lake is the information that besides the lake being used in the summer for the practice of water sports, it is also used for bathing.

The radiometric measurements were performed in situ in time bands from 12:00 to 3:00 p.m., so that it was also possible to observe the variation of the reflectance in the schedules.

Fig. 3. Quinta da Boa Vista lake

Fig. 4. The opaque coloration of lake waters. This fact make it impossible to see the lake bottom

RESULTS / DISCUSSION

Following the sequence of measurements in the respective time bands, some results were observed and presented in Figure 5. It is possible to check, in general, some important characteristics of the presence of chlorophyll-a associated to pigments that act in the photosynthesis and cause the decrease of the reflectance in the spectral bands of blue (400-515 nm, feature "A") and red (660 - 670 nm, feature "D") and increase in the green band (515 - 600 nm, feature "B"). In these Figures the six characteristics of significant absorption and reflection in the spectral response of water are shown: A, B, C, D, E and F features (Rundiquist *et al*., 1996)]. Another common factor among the reflectance measurements made in the lake is that the "A" feature, which characterizes the presence of chlorophyll in the water, indicates low reflectance between 400 and 500 nm due to the absorption of blue light, with a minimum of 441 nm. It is also possible to observe a peak of reflectance in green between 560 and 570 nm, feature "B", and a small inflection point at approximately 640 nm, feature "C" due to backscatter caused by accessory pigments or dissolved organic material. The "D" feature corresponds to an absorption point in the red, at approximately 676 nm, associated to the second point of maximum absorption by the presence of chlorophyll-a. The "E" feature represents a well-defined near-infrared reflectance peak around 700 nm, and finally a smaller peak, "F" feature, at about 810 nm, probably caused by backscattering of organic matter (algal cells) , combined with absorption by water in the infrared (Rundquist *et al*., 1996).

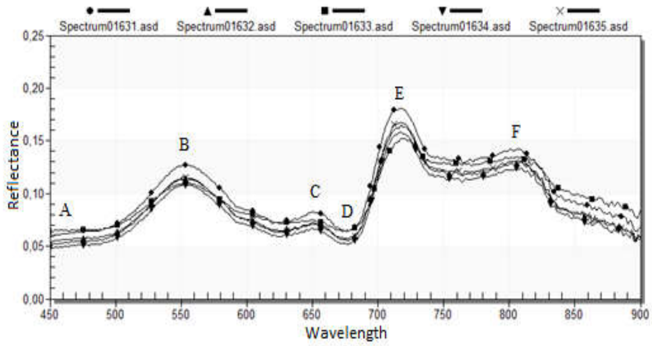

Fig. 5. Reflectance measurements taken at Quinta a Boa Vista lake

In relation to the presence of chlorophyll-a, the comparison with its absorption spectrum shown in Figure 2, can be observed in Figure 5 the characteristic of its strong absorption in the region of red and also near the region of the blue. The absorption of chlorophyll is very low in the green region, a fact by which chlorophyll shows this coloration.

Conclusion

The use of the tripod spectroradiometer with an oblique view, with the purpose of carrying out the study of a selected water region, presented its great utility and importance. This experiment showed that it is possible to detect immediately the presence of optically active components and specifically chlorophyll-a in the analysis of the Quinta da Boa Vista lake.
Radiometric measurements with an oblique view did not present problems or alterations in the chlorophyll-a detection process by analyzing the spectral behavior of the water region evaluated. The study has proven that from in *situ* measurements of the water reflectance factor, it is possible to

identify environmental parameters associated with poor aquatic quality. Consequently, the methodological strategy being studied has proved appropriate for the identification of the presence of chlorophyll-a in water. In this way, it will be possible to carry out their respective quantification, in order to be able to evaluate the quality of the water from the presence of this variable.

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