AN INTERACTIVE WEBGIS PLATFORM FOR ENHANCED SUPPORT OF INTEGRATED ENVIRONMENTAL MANAGEMENT OF AQUACULTURE

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ABSTRACT

This study aimed to show a system integrated environmental management of aquaculture for the public authorities and general public to monitor water quality and the land use in hydroelectric reservoir. Water quality monitoring that use standard operating procedures for sample collection and analysis, an interactive and flexible application module and WebGis platform was investigated in tilapia cage farms in Ilha Solteira Reservoir. The preliminary results indicated that in most case fish farm sites reflected water quality of its respective rivers, and the current developing system, can help organizations and government policies in managing and analyzing relevant data to make decisions that regulate the assignment of public waters to aquaculture.

Key words — fish farms, water quality, monitoring, reservoir, geospatial information.

1. INTRODUCTION

Worldwide, current population growth and per capita growth fish consumption will demand technology and water resource to be more efficient in term of food production in a global scale [1]. Rising demand is pushing up fish farm expansion in Brazil, in particular tilapia cage farms in large hydroelectric reservoir [2]. In 2017 the growth was 8% in relation to the year reaching a production of 640,410 tons, placing the country as the fourth largest producer of tilapia in the world, behind China, Indonesia and Egypt respectively.

However, aquaculture can cause impacts on the water quality of the reservoirs, such as the reduction of dissolved oxygen, eutrophication [3; 4], excessive toxic substance and frequent fish diseases. In order to meet market demands and annual activity expansion rates, it is necessary to adopt productive practices supported by innovative environmental monitoring systems to optimize the management and environmental management of aquaculture [5]. The current study aimed to show a reservoir water quality monitoring that use standard operating procedures for sample collection and analysis, an interactive and flexible application module and WebGis platform called AgroTagAQUA as a cost efficient tool to monitor all the requested issues. The AgroTagAQUA (https://www.agrotag.cnptia.embrapa.br) is framework developed by Brazilian Agricultural Research Corporation – EMBRAPA, and Plataforma ABC (Multi-institutional monitoring of greenhouse gas emission reductions in agriculture) in the scope of research project BNDS/BRSAqua-Component project Environmental Management of Aquaculture .

2. MATERIAL AND METHODS

Study area is located in Ilha Solteira hydroelectric Reservoir at Paraná River, Brazil (Figure 1). The region has a tropical climate – Aw (Köppen's classification), which is characterized by a rainy summer and dry winter, with an annual mean temperature of 23.7 °C and annual rainfall of 1,300 mm.

The Reservoir is inserted in a priority place of action to promote aquaculture in Brazilian government, through the implementation and monitoring of parks for the aquaculture production of tilapia cage farms [6]. Nile tilapia (*Oreochromis niloticus*) production in Brazil features the highest growth rate in the world [1].

At the reservoir, the sites were defined by stratified random sampling method applied to orbital images from Landsat-8/OLI sensor which consisted in samples sites selection through the radiometric signal variation among the visible and infrared bands [7]. Site selection resulted in identification of 18 sites, i.e. 12 sites in River Paranaíba (referred to as S6-S8 and S12-S20), six sites in River Grande (S25-S30) (Figure 1). All selected sites are former influence area of main rivers, flooded since the formation of Ilha Solteira Reservoir. It were also selected sites where there are currently tilapia cage farms operating: five sites in the Cupins (S1-S5) and three sites in the Formoso (S9-S11), both localized at River Paranaíba; and four sites in the Cãn Cân (S21-S24), the most important fish production are of reservoir localized at River Grande (Figure 1).

We evaluated water quality in June/2018 at each site, and measured the following limnological parameters: depth using a Speedtech sonar (depthmate Portable Sounder), water transparency using a Secchi disk. Water temperature, pH, conductivity, turbidity, and dissolved oxygen using a calibrated Multiprobe YSI (Model 650 MDS) water analyzer. Water samples were obtained from the surface (Van Dorn bottle) for assessing the concentrations of pelagic phytoplankton—chlorophyll-a [8]. Total nitrogen and phosphorus are still in laboratory analysis, and we do not show data. All quantifications were made in triplicate.

Whereas analysis of spatial distribution is a key point in monitoring activities, continuous surfaces for each collected variable were estimated using Inverse Distance Weighted (IDW) technique. Interpolation method selection took into account the computational simplicity, an important feature in systems applied to management and decision making, since these systems require velocity and update in data and available information. In addition, the previous sampling plan carried out ensure variability among the samples and avoid the cluster effect, which makes IDW appropriated to be used as interpolator.

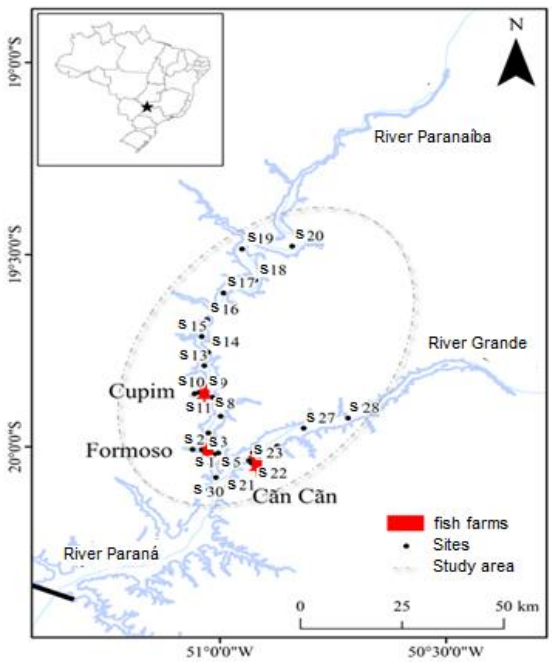

Figure 1. Study area and sites in the Ilha Solteira Reservoir

3. RESULTS AND DISCUSSION

From the Figure 2, information on the limnological parameters can be processed and visualized as different GIS layers. Mean depth presented widely variation among sites. Water temperature values were lower in the River Grande than River Paranaíba, with lowest values at sites 21-24 in the Cãn Cãn fish farm. The mean water transparency were higher, and turbidity were lower in the River Grande than River Paranaíba. Conductivity values were highest in the River Grande 70 µS/cm. At the River Grande and sites 21-24 in the Cãn Cãn fish farm, pH and was neutral, whereas was lightly acidic in River Paranaíba (S6-S8) and sites in the Cupins (S1-S5) and Formoso (S9-S11) fish farms. The dissolved oxygen values were lower in the River Grande than Paranaíba, with lowest values at sites 21-24 in the Cãn Cãn fish farm. Chlorophyll-a values were lowest in the River Paranaíba (S12-S20) upstream Cupins (S1-S5) fish farms. The observed values of the respective parameters were in accordance to the CONAMA resolution 357/2005 [9] for water bodies class 2 intended for fishing activities, with exception of pH values. Our preliminary results suggest that in most case fish farm sites reflected water quality of its respective rivers.

In this sense, these types of results will be important for making decisions about the expansion of new fish production areas within the reservoirs of interest. Since 2004, the Brazilian government has delimited six reservoirs (including Ilha Solteira) totaling 28,503 hectares of water, in which 42 aquaculture parks have been installed [6]. In this sense, the BNDS/BRSAqua Project supporting the Brazilian Aquaculture Environmental Monitoring Network, by development standard operating procedures for sample collection and analysis, and the AgroTagAqua WebGis interface for data access to users, with different needs (e.g., water body managers, water utilities, general public) using different platforms (desktops, tablets) (Figure 2).

The online system will aggregate the collected and reported results of the project and compiled secondary data, such as satellite images, census data and strategic data for integrated analyzes, e.g., reservoir boundary, boundary municipalities, river basins. Primary data, e.g. water quality, can be processed and visualized in WebGis interface, and allow users access and decision making, since these systems update in data and available information. The system also allows thematic integration procedures in the web and results of interest can be made available through the application to user access in the field (Figure 3). Other data, such as the Sentinel satellite with data of 10 meters resolution, are being evaluated for monitoring fish farms operating, strengthening the Monitoring Network with updated information on the spatial distribution of fish farms production.

Fish farmers reported having changed the production location to a different geographical area due to environmental issue, such water level change associated influenced by the operation of water level reservoir by the hydropower energy company. This procedure causes daily declines in the water level of fish cage areas which affects fish productivity and health. This kind of information can be update to WebGis, by hydropower Energy Company, and fish farmers have access to database concerning environmental aspects of the reservoir. Therefore, the system integrated environmental management of aquaculture allows a continuous Monitoring Network with updated information to of users, with different needs.

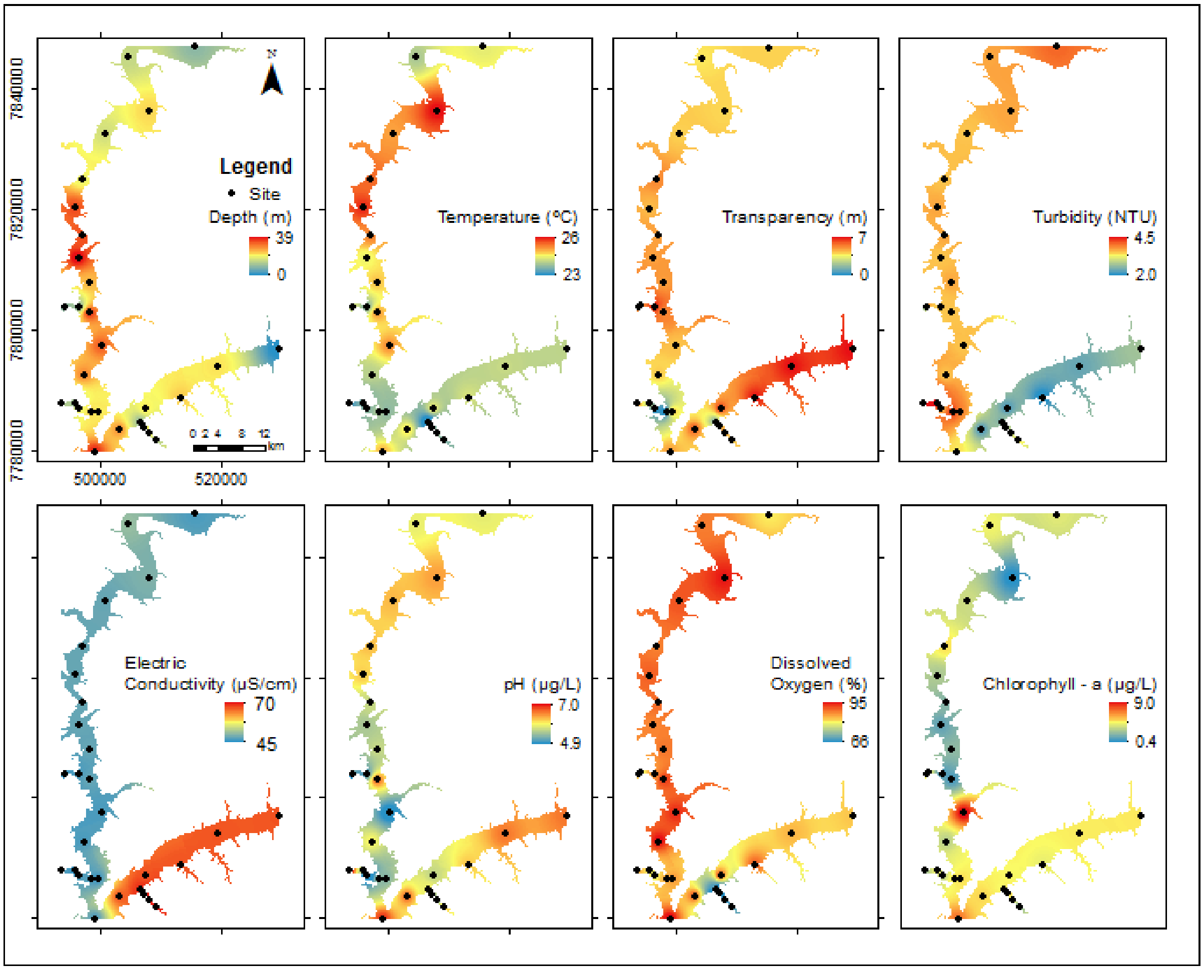

Figure 2. Water quality map

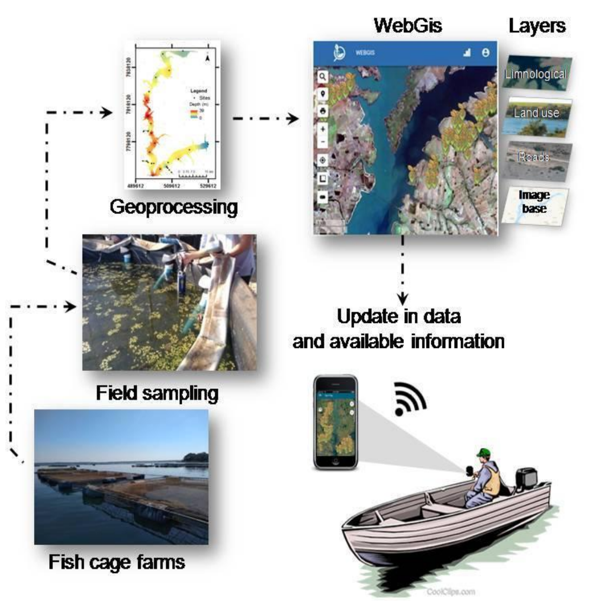

Figure 3. Water quality map can be visualized in WebGis interface

To support the integrated environmental management of aquaculture, the AgroTagAqua app, in development, will contain thematic forms, with questions related to fish farm productivity. This technology is increasing opportunities for crowdsourcing water quality data, and lays out a strategy for citizen engagement in decentralized water quality monitoring. The crowdsourcing, collected by local fish farmers, partners and technicians, allows for data collection over vast swaths of area and at various times for less cost. This information will feed the WebGis database and enable integrated analyzes with the other geoinformation in the database. The app also has a land use and coverage protocol for collecting information about the reservoir environment, focusing on the analysis of the influence of land uses on water quality indicators.

4. Final Remarks

The system integrated environmental management of aquaculture improves the efficiency dissemination of information to the fish farmers and organization, and in particularly government policies that regulate the assignment of public waters to aquaculture.

5. ACKNOWLEDGE

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