Environmental diagnosis of the soil usage and the water resources preservation of Juqueriquerê river's watershed

José Nunes Pinto Neto
Master in Environment and Water Resources, Natural Resources Institutes, Federal University of Itajubá, BPS Avenue 1303, Zip Code 37800-000. Itajubá [MG], Brasil. <neto_unifei@yahoo.com.br>.

Luciana Machado Moura
Master in Environment and Water Resources, Natural Resources Institutes, Federal University of Itajubá, BPS Avenue 1303, Zip Code 37800-000. Itajubá [MG], Brasil. <lucianambiental2008@yahoo.com.br>.

Gisele Aparecida Fernandes
Master in Environment and Water Resources, Natural Resources Institutes, Federal University of Itajubá, BPS Avenue 1303, Zip Code 37800-000. Itajubá [MG], Brasil. <giseleunifei@gmail.com>.

Alessandra Rodrigues de Carvalho
Master in Environment and Water Resources, Natural Resources Institutes, Federal University of Itajubá, BPS Avenue 1303, Zip Code 37800-000. Itajubá [MG], Brasil. <arcarvalho@unifei.edu.br>.

Marilu Alcântara de Melo Figueiredo
Master in Environment and Water Resources, Natural Resources Institutes, Federal University of Itajubá, BPS Avenue 1303, Zip Code 37800-000. Itajubá [MG], Brasil. <marilualcantara08@gmail.com>.

Elaine Dias de Faria
Master in Environment and Water Resources, Natural Resources Institutes, Federal University of Itajubá, BPS Avenue 1303, Zip Code 37800-000. Itajubá [MG], Brasil. <elainedfaria@gmail.com>.

Nívea Adriana Dias Pons
Professor, Environment and Water Resources, Natural Resources Institutes, Federal University of Itajubá, BPS Avenue 1303, Zip Code 37800-000. Itajubá [MG], Brasil. <niveadpons@gmail.com>.

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Abstract
The management of the soil usage and the water resources protection has received more and more attention from society and environmental studies. In this perspective, geo-processing tools can help in the production of more representative diagnosis, reporting the reality of the study fields in a clearer way. This paper aims at performing a diagnosis of the soil usage as well as the state of preservation of the water resources of Juqueriquerê River's watershed. To create the database and the final production of the maps, the following programs were used: Google Earth Plus, Global Mapper 13 e ArcGis 9.3. The analysis of the data allowed the contrast between the degradation areas which extend from the central area of the basin to the edge of the Atlantic Ocean, such as many pasture areas and degraded riparian, which compromises the quality of the water resources. Safety policies, respect of the soil usage and the proper application of environmental management plans are essential to achieve the correct use of the natural resources.

Keywords
Environmental Studies, Geoprocessing, Environmental management plans.

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Introduction

In the past decades, discussions about the environment received worldwide prominence, mainly in what refers to its biodiversity protection and conservation. However, the Brazilian society started to express concern only after the growing number of scenes of water shortage, soil degradation, atmospheric pollution, and others (FUJACO; LEITE; MESSIAS, 2010).

According to Santos et al. (2012), it is primordial to perform the planning and the handling of the soil, on a conservative basis, in order to recover degraded areas and preserve the environment. The process must start from the diagnosis of the natural resources of the applicable area, mainly the soil attributes that manage its usage capacity.

Nascimento et al. (2005) highlights that the destruction of the vegetation that protects the water resources affects the environmental balance of the drained areas by the watersheds and decreases the quality of life of the population.

According to Júnior et al. (2010), the Permanent Preservation Areas (PPAs) are regions covered or not by native vegetation with the environmental role to protect the landscape, the water resources, the geological stability, and the genomic flow of the fauna and flora, the soil, ensuring the wealth of the human populations. They are located at the edges of rivers, streams, lakes, dikes and other bodies of water in areas of variable width at the steep slopes, mountaintops, apart from other places specified by the Forest Code.

According to Tonello (2005), the watershed can be conceptualized as a planning unity, whose the discipline of its usage and the occupation of the soil are the most effective means of preservation of the water resources which compose it. In the management of watersheds, the integration and the analysis of a large amount of information in a conventional way are considered difficult and they take a considerable amount of time. Nevertheless, when information is represented spatially using maps, through the SIG tool, it generates great potential for data integration, supporting and subsidizing basin management.

According to Tonello et al. (2009), some regions adopted the property and the community as units of planning in order to accomplish the work of soil and water conservation. These limits don't correspond to the natural ones. The environmental planning based on watershed has the advantage of grouping the actions in a previously specified geographic area with the help of topographical letters and set by the water divisors, where the rain waters come from to the lowest parts of the land creating the water flows.

According to Soares et al. (2011), the delimitation credits of PPAs, based on topography, require the participation of specialized crew and detailed information of the spatial unit in analysis. It's been observed, in this scenery, the importance to provide the enforcement agents with accurate maps, indicating the real limits of the areas, in order to preserve the natural resources. However, the main challenges pointed out by the governmental agencies are the lack of procedures and the required structure to assess with the due accuracy the aggressions against the environment. Thus, the use of applicable methodologies to be implemented via geo-processing is a viable alternative, which aims at reducing the relative deficiencies in the non-compliance of the relevant laws (NASCIMENTO et al., 2005).

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The geo-processing is a tool that holds, quantifies and manipulates geo-referenced data, crossing and statistically treating this information. The application of geo-processing techniques, along with the remote sensing and Geographic Information System (GYS), have contributed to the achievement of numerous studies in the vast field of science and in the environmental area particularly (FUJACO; LEITE; MESSIAS, 2010). Grounded in the environmental legislation, it can allow the public power to verify the feasibility of projects and the occurring of inappropriate usage of the land (OLIVEIRA et al., 2008).

The aim of this work is to diagnose the current preservation of water resources in the Juqueriquerê River's watershed. Despite being the largest basin in the northern coast of the state of São Paulo, there are few studies about this watershed. Both facts support the importance of this research.

The biggest part of the watershed is located in the city of Caraguatatuba (SP), where the degradation of water resources is already known due to the low level of collection and treatment of sewage and beaches with compromised bathing.

Study area

Juqueriquerê River's Watershed, Caraguatatuba (SP).

The city of Caraguatatuba is located in the northern coast of the state of São Paulo, bathed by Juqueriquerê River. It has a population of 100.840 inhabitants and covers an area of 485,377 km^2, with demographic density of 207,76 inhabit/km^2 (IBGE, 2010).

The rivers from the northern coast of São Paulo are located at the Atlantic Southeast Hydrographic Macro Region, whose total area covers 229.972 km^2, representing 2,7% of the total of the country. The city of Caraguatatuba, along with Ubatuba, São Sebastião and Ilhabela, belong to the Water Resources Management Unit of the Northern Coast (UGRHI-3), the smallest of the state, with an area of 1.977 km^2. Caraguatatuba displays a specific vocation to environmental preservation, tourism and navigation (commercial and sportive) (SÃO PAULO, 2007).

The Juqueriquerê river covers an area of 429,8 km^2 and constitutes the biggest sub-basin of the northern coast of São Paulo (ANA, 2012).

Juqueriquerê river rises in Serra do Mar and flows into the beach of Porto Novo in Caraguatatuba, covering around 13 km. It is the largest navigable river of the northern coast of São Paulo. It is formed by the junction of Pirassununga and Camburu Rivers. Its depth varies from 1.3 to 2.1 meters. In its mouth, quite silted in periods of low tide, its depth is only 30 centimeters. It has mangroves and rich flora and fauna (PETROBRAS, 2007; SÃO PAULO, 2007).

While the sub-basin has an average flow of 19,60 m^3/s to 40 m^3/s, Juqueriquerê river displays an average flow of 10,81m^3/s. Therefore, it has the biggest hydro availability of the region (SÃO PAULO, 2007).

All those cities that constitute the UGRHI-3 use the superficial waters mainly for public provision, rural (consumptive uses), recreation and leisure, fishing and the dilution of domestic wastewater, in addition to the maintenance of the fluvial biodiversity (non consumptive uses). The irrigation and watering of animals of this region are not very significant (PETROBRAS, 2007).

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Impacts such as inappropriate littering of sewer and solid leavings, dredging, sand removing, erosion, slurry, burnings, irregular occupation of the preservation areas, besides contaminations from the washing of vessels in the marinas, have contributed to damage the quality of the river. Furthermore, the river bathes some of the most populated neighborhoods of the city, in addition to the existence of a series of marinas, hotels, resorts, motel inns and clubs at the edge of the river (SÃO PAULO, 2007).

According to IBGE (2010), there are about 4.190 houses in the urban area of Caraguatatuba with open-air sewer systems; 14,25% of the urban population have access to the water distribution net. Nonetheless, they have no piped sewer systems and 0,076% of the people do not have bathrooms at their homes.

In relation to the basic sanitation, the population contingent and the time of the year must be taken into account because the number of residents and tourists varies in the summer, the latter being responsible for an increase of up to 9 times the number of inhabitants in the high season. The standard of the health care system is quite poor, reaching about only 17% of the population. About 80% from UGRHI area and of anthropic use (SÃO PAULO, 2007).

Materials and Methods

At first, the Watersheds Maps of the Northern Coast were obtained from the website of the Committee of the Watersheds of the Northern Coast. These maps were uploaded to the Global Mapper 13, performing the geo-referring and vectorization of Juqueriquerê River's watershed. Then, this vector was uploaded to Google Earth Plus, extracting air images with enough resolution to set out the different kinds of soil coverage. These letters were saved in "jpeg" format, and then they were uploaded and geo-referenced to Global Mapper 13. After the correct assignment of coordinates and setting of the air image mosaic, its vectorization was performed, where 5 coverage levels were defined: dense vegetation, pasture, exposed soil, urban area/buildings and industry area. The drainage of the basin was obtained from the digitalization of IBGE letters, with original scale of 1:50.000, when these letters were uploaded and geo-referenced in Global Mapper 13, making it possible to perform the vectorization of the water resources. Finally, the drainage was adjusted to the air image mosaic, in order to reduce possible bias from different projections, geo-processing, etc. All the vectorial files were exported into the "*shapefile*" format and uploaded to the software ArcGis 9.3, where the previous map of the usage of the soil of the related watershed was used. To build the final map, a field campaign was done on July 15th and 16th 2013, when it was possible to perform the actual truth of the mapped data. As a consequence, the final map of usage of the watershed from Juqueriquerê River was created.

Through the database that contains the drainage, buffers of 30 and 50 meters were performed with the help of ArcGis, corresponding to the permanent preservation areas of riparian vegetation and springs, respectively. Then it was performed (in ArcGis 9.3) the multiplication of this new database with the map of usage of the soil, created previously, making it possible to obtain a map which contains the usage of the soil inside these areas of permanent preservation.

Results and Discussion

After the field campaign and the final creation of the map of usage of the soil through a detailed mosaic, as suggested by Soares et al. (2011), it was possible to verify that

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Juqueriquerê River's watershed has a net of drainage covering over the mark of 800 km when arranged in a straight line (Figure 1). The natural coverage of the most part of this basin is preserved, where dense vegetation areas reaches the entire region located at Serra do Mar, as well as the edges of the northern and southern borders. However, these preserved areas contrasts with degradation areas present from the central part of the basin up to the edge facing the Atlantic Ocean (Figure 2). This region encloses two strands that must be highlighted: the urban area of the city of Caraguatatuba (SP) and Serramar Livestock. Regarding the urban area, it was possible to check that it occupies approximately 6% of the total area of the Juqueriquerê River's watershed. As usual, urban areas tend to contribute to the degradation of the natural resources, once they need to expand for civil building constructions and they receive a large quantity of people. Thus, the mass creation of the most variable types of residues is inevitable, compromising the environmental quality as a whole. The city of Caraguatatuba has an aggravating circumstance for being bathed by the sea – it receives a large number of tourists yearly, and they contribute to the production of residues. In addition, only 45% of the sewer is collected (SABESP, 2011), and the remaining 55% is disposed in the rivers and beaches of the region.

As for Serramar Livestock, it has been observed that the activities from this area can contribute significantly to the degradation of the water resources of the watershed. By analyzing Figure 1, it's possible to notice that there are approximately 55 km² of pasture inside Juqueriquerê River's watershed. Most of this area seems to belong to Serramar Livestock. In addition, inside the same property it was possible to notice the presence of big areas of exposed soil and also the existence of industrial activities, apparently mining, located at the edge of contributors to Juqueriquerê River. Due to hindrances, it was not possible to perform the ground truth in these regions, because they are private properties.

The reported degradations by the map of usage of the soil (Figure 1) are reflected in the permanent preservation areas, as seen in the Figure 2. It was possible to notice nearly 87% of the permanent preservation mapped areas. The classification of the most visible degradation was pasture (nearly 10%), followed by urban areas/building constructions (nearly 3%), exposed soil (nearly 0,5%) and industry area (nearly 0,1%). Nevertheless, it is important to highlight that most of the classifications of pasture and exposed soil in areas of PPA seem to be the result of activities performed by Serramar Livestock, as well as the degraded area caused by their mining activities.

As mentioned by Santos et al. (2012), the planning of usage and maintenance of the soil is essential to recover degraded areas and preserve the environment. From this point of view, zoning practices for the city of Caraguatatuba (SP) and functional environmental plans of management of the activities of Serramar Livestock are essential for the recovery of the degraded mapped areas, especially for those located in PPAs. It is vital that Serramar Livestock follow appropriate Plans of Environmental Control (PECs) to reach a good balance between their activities and the environment where it operates. These PECs must encompass mitigating and compensatory measures, thus ensuring their commitment with the environment and the preservation of the water resources that bath Juqueriquerê River's watershed.

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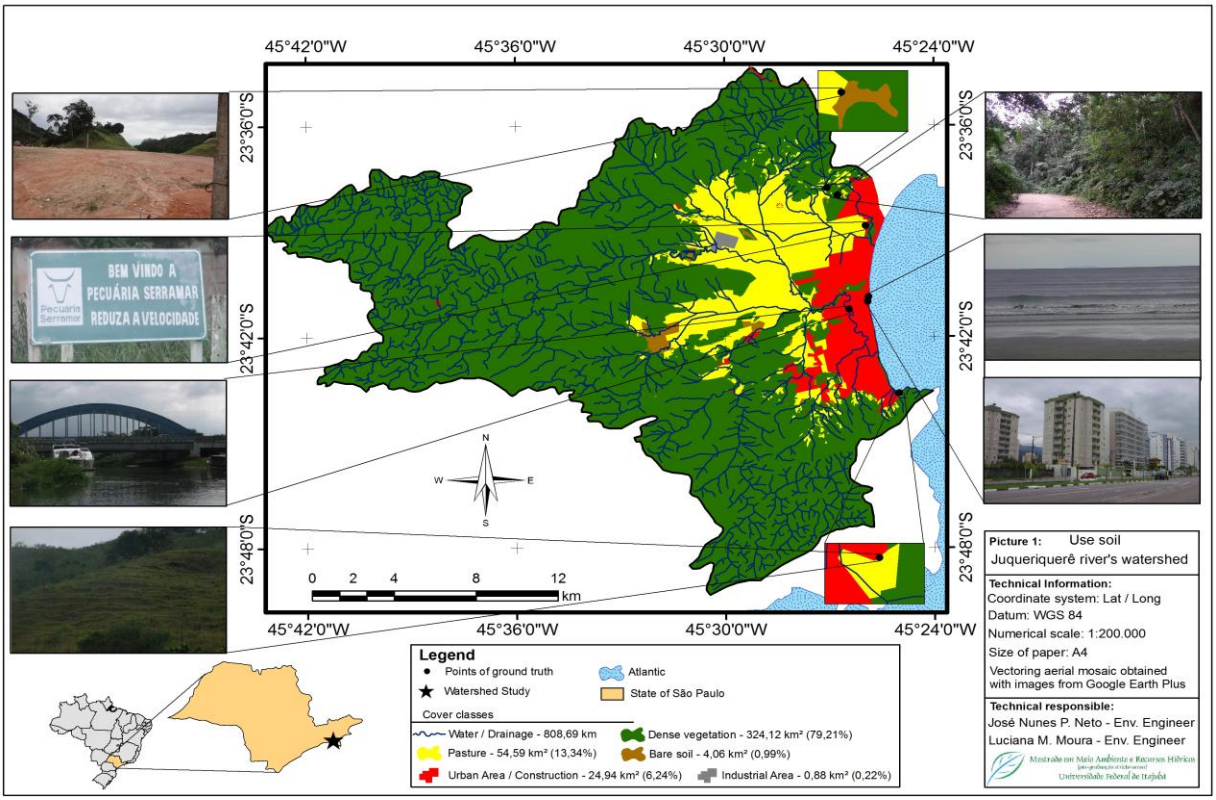

Figure 1. Use soil Juqueriquerê river's watershed.

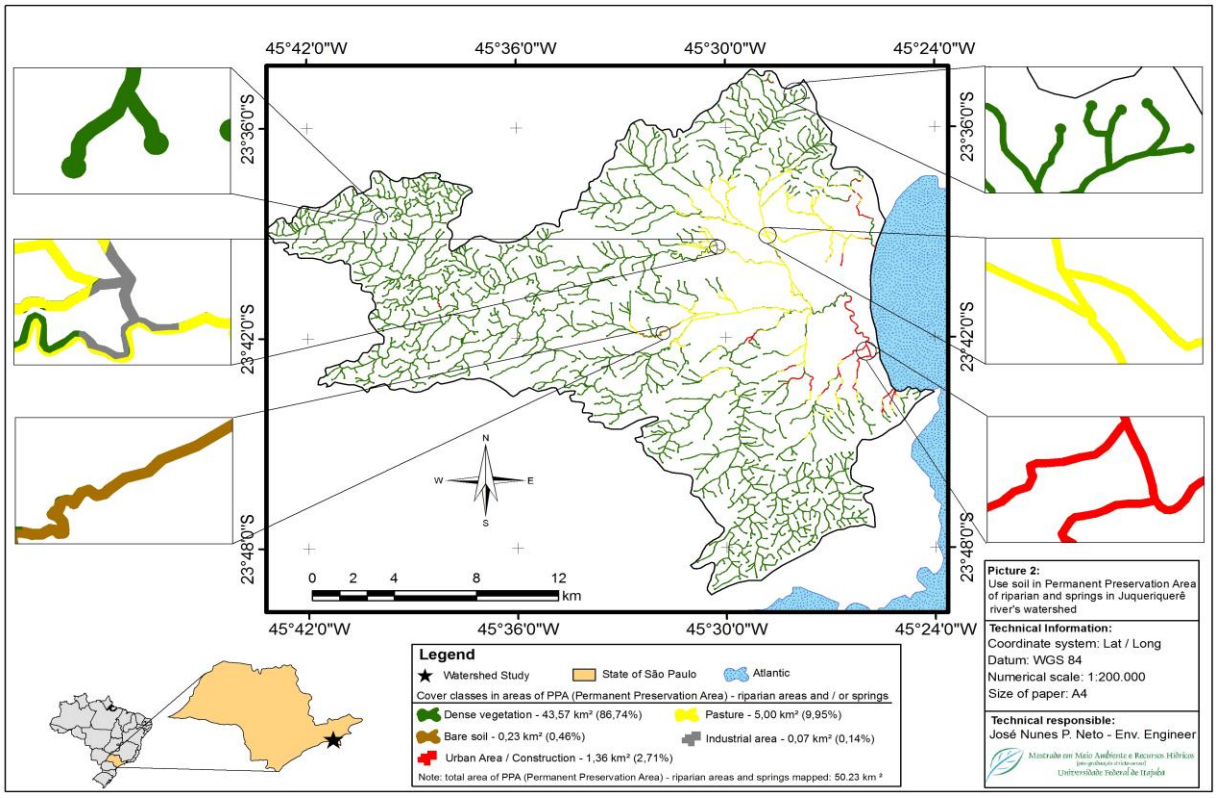

Figure 2. Use soil in Permanent Preservation Area of riparian and springs in Juqueriquerê river's watershed.

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Conclusions

The use of the geo-processing tool made it possible to perform the mapping of the usage of the soil of Juqueriquerê River's watershed, as well as its PPAs regarding the area of riparian and water risings. Through the mapping, it was possible to notice that a large area of the studied basin is found in a preserved state, while the attributed degraded areas are mainly the anthropic occupations and Serramar Livestock's activities.

The creation of the maps made it possible to identify water rising areas and degraded riparian. To counteract or at least diminish these environmental impacts, it is necessary to implement measures such as zoning, respect towards the usage capacity of the soil, etc. The anthropic intervention in these PPAs areas compromises the quality of the water resources, thus urging these regions to become constantly preserved.

In regard to Caraguatatuba (SP), in particular, it is essential to implement public policies in favor of waste and sanitation management, mainly in periods of high season, when the level of pollution worsens because of the floating population.

The correct environment management must be a Constant in all performed anthropic activities. Safeguard the usage of natural resources for our future generations is a duty of our society, helping to set sustainable development and ideologies further and further apart.

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