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SILTATION AND EROSION PROCESSES ON A TRIBUTARY OF LAKE ITAIPU DUE A DAM RESERVOIR

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Abstract

It is known that sediments in the river have their origin from different sources. Therefore, the proportion that each source contributes to the mix varies over time and space, as a result of erosion processes that are ongoing in the basin of contribution. Within this context, both in human actions in urban and rural watersheds generate different rates of sediment production, but mainly with different characteristics or quality. Thus, the fluvial sedimentology should have a broad character within the study area and check all the possible influences of land use and soil. Hydrosedimentological processes are complex and include a disaggregation ("erosion" in the strict definition), transport, sedimentation, consolidation of sediments. Therefore, it is necessary more detailed studies of sediments and their interactions with the environment, considering it as a topic of interest to economic, social and ecological needs of a sustainable management, where they articulate an understanding of the physical and chemical properties of sediments with ecological and hydrological information of the water bodies receiver on a regional scale and thus evaluate the possible scenarios of pollution of water resources. This information will support in decision-making processes for managing the watershed and its water resources. Therefore, this project aims to determine the interference that a hydroelectric plant, together with the lack of proper management of the basin, can cause to the river morphology. The research is conducting a survey of sensitive areas to erode and the influence of a newly installed hydropower in a tributary of Lake Itaipu. Could notice that the removal of riparian vegetation is accelerating the erosion processes at various points of the river, but the agriculture system used in the rural area, without revolving of soil, has reduced the sediment load produced by this source. However, the retention of much of the coarse sediments by the new dam is creating an imbalance between the small amount of sediment transported after the hydroelectric and flow transport capacity. There are two cases occurring in a dam: 1) the dam upstream has a reduction of velocity and it start a process of sedimentation that will accelerate its siltation and reducing its useful life, 2) dam downstream has water velocity again and then initiate erosion process due the lack of sediments in the liquid mass. It can be concluded that changes of use and occupation of land in the watershed generate

increased occurrence of peak flow and sediment transport, but the inadequate management of the area (with removal of riparian vegetation and lack of energy sinks in outputs of drainage systems) potentiates the increasing the instability of water bodies morphology. In case of presence of reservoirs, the alterations are worst because they create siltation and erosion process at the same river.

Keywords: sediments, water resources management, siltation, erosion, fluvial morphology.

1 INTRODUCTION

It is known that sediments in the river have their origin from different sources. Therefore, the proportion that each source contributes to the mix varies over time and space, as a result of erosion processes that are ongoing in the basin of contribution (Poleto et al., 2009). The rapid, spontaneous and disorderly caused the swelling of many cities, characterized by the occupation of outlying areas, most unsuitable for building. This has had serious consequences for the environment, with significant loss of quality of life in these urban spaces.

According to Alves (2000), the urbanization process-periphery is continuous and expansive, leaving scholars to intervene in this process as their abilities and awareness. But it is known that the difficulties are numerous, especially as regards the inappropriate occupied areas.

Chaos installed these so-called "urban areas", got their start when changing the natural cover of layers of waterproofing works and constructions of the soil. The consequences do not always occur over a long period of time, because with these changes the use and occupation, begins major changes in hydrological characteristics, such as decrease in infiltration rates and increased runoff, therefore there is an increase in peak flow rates, and issues that gain greater public sensationalism, such as flooding, enter the media.

The increased frequency of floods, streams and rivers silted and polluted, gullies and diseases are part of the reflections of disorganized occupation of urban space. The variables of the cycle of urban watersheds represent hydrosedimentological metabolism unsustainable urban growth characterized by population growth, urban sprawl and suppression of critical natural environments.

Overall this complex process of expansion, forget that water is essential for the survival of any species, leaving the same into a state of accelerated degradation, and with it all the area tends to decline with respect the ecological aspects. Historically, studies of water quality returned only for drinking water as if it were a single component, with the motivation to

concern for human health, but now attention is being transferred to the protection of other ecosystem components, such as sediments and soils, which is directly related to that quality.

The sediments contaminated with heavy metals have been considered as one of the biggest environmental problems. In this context, studies of sediment quality have become an important focus in environmental assessments, management and protection of aquatic ecosystems. According to Banerjee (2003), most studies on heavy metal concentrations in urban areas has been conducted in developed countries and few studies are found in developing countries.

Environmental problems related sediments are particularly important in developing countries, since the rate of population growth in these countries is almost always very high, and this is a proportional increase pressure on natural resources that cause the increase in production rates of sediment (Syvitski et al., 2005).

Thus, the existence of several areas with exposed soils, lack of urban infrastructure (street paving, drainage and sewage), civil construction without a strict control against erosion and lack of water works that store sediment from the floors (sand boxes) during the precipitation, transforming those in large urban areas producing sediment, and therefore metals and other pollutants can be transported to the river channel.

So when you think of sediments, one must remember that the subject is too vast and that it interacts in different ways with the environment and living beings that surround him. Sediments provide habitat and nutrient source for many benthic organisms and are an important component of the aquatic ecosystem (Environment Canada, 2003a). Moreover, the pellets also influence the accumulation of toxic and many accumulative aquatic ecosystems (CCME, 1995). Consequently the sediment can act as a long term source of these substances into the environment affecting water quality and aquatic population (Poleto & Merten, 2007). This concern is mainly related to persistent toxic substances, those substances that take a long time to be released when the associated sediments, since these are usually bioaccumulative and contaminate organisms that feed on or are in contact with these contaminated sediments. According to Banerjee (2003), urban systems are highly sophisticated and complex, where contamination with heavy metals causes a major concern due to its toxicity and imminent threat to human life and the environment.

Still, most studies with heavy metals associated with sediments in suspension and/or the bed, evaluating only concern themselves with the total concentrations of these metals, which is not always sufficient. Given the problem of sediment contamination by heavy metals and other toxic

substances in many studies or progress on this subject (Hursthouse, 2001), note that these contaminants can be found in various forms, and the use of total concentrations as a criterion to assess its potential effect to pollute the aquatic environment, implies that all forms have the same impact on the environment, which according to Tessier et al. (1979) is untenable.

Currently, it is known that the behavior of trace metals in the environment is determined by its specific physico-chemical form rather than its total concentration (Tack & Verloo, 1995). This generates a great motivation for the study of heavy metals in sediments, is accomplished by sequential extraction, as this gives a qualitative idea on the reactivity and mobility of metals from sediments. Future data can improve the prediction of changes in water quality through more accurate modeling of environments that are potentially contaminated.

The transport of sediments affect water quality and the possibility for human consumption or used for other purposes. Many industrial processes do not tolerate even small amounts of suspended sediment in the water. This fact often involves massive public spending to solve the problem, and these could be reduced with proper management of the urban environment. In addition, erosion and sedimentation exacerbate the instability of the river channel (Poleto, 2011).

Therefore, this project aims to determine the interference that a hydroelectric plant, together with the lack of proper management of the basin, can cause to the river morphology.

2 METHODOLOGY

For this project, field surveys were conducted throughout the various bodies of water forming the lake's dam, as shown in Figure 1.

The study area has 548 km² and is located in Parana state, southern Brazil. We used GPS, camera and equipment for collecting bottom sediments (Helley-Smith) for the years 2009, 2010 and 2011. The sediments were sieved to separate the different particle sizes and the percentage of them was calculated.

The data were released on satellite image to perform the data distribution and location of major erosion problems found in the watershed.

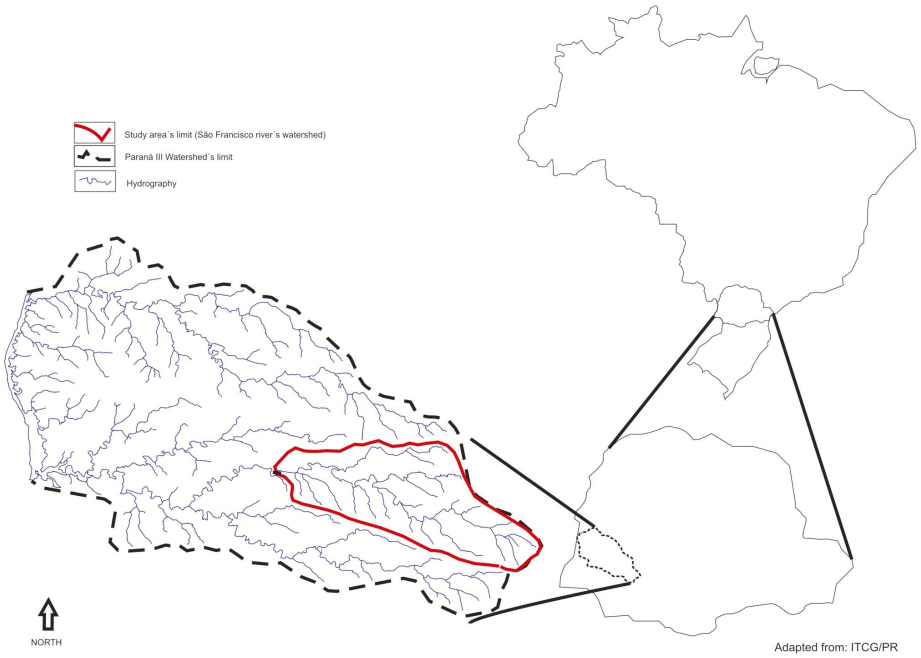

Figure 1. Study area localization in Brazil.

3 RESULTS AND DISCUSSION

Field studies showed a great change in the basin, with a great diversity of types of crops of plants (Figure 2) and with the inclusion of large animal breeding, which has expanded more.

Figure 2. Removal of areas of industrial minerals and materials near the springs of water bodies

The cities that are located in this basin are also in rapid growth and expansion (Figure 3) due to heating of the national economy and increasing the capacity of Brazilian consumption.

Figure 3. Expansion of urban and agricultural crops with significant reduction in natural vegetation.

In Figure 4 is possible to see the soil uses and the urbanized area. Table 1 presents the percentage of each kind of use.

Table 1 – Percentage of each kind of use of soil in the study area

Description of soil use	Percentage
Urban area	12.55%
Reforestation	0.61%
Exposed soil	9.31%
Aviary	1.52%
Natural forest and riparian	7.85%
Agriculture	68.13%
Sewage treatment plant	0.03%

The analysis has presented the only 7.85% of natural forest and riparian areas. This percentage is less than exposed soil (9.31%) that is the worst situation for the water bodies. Large areas used for agriculture (68.13%) and exposed soil represent the major font of sediments and without enough riparian areas to retain them, so the water bodies receive a large load of sediments.

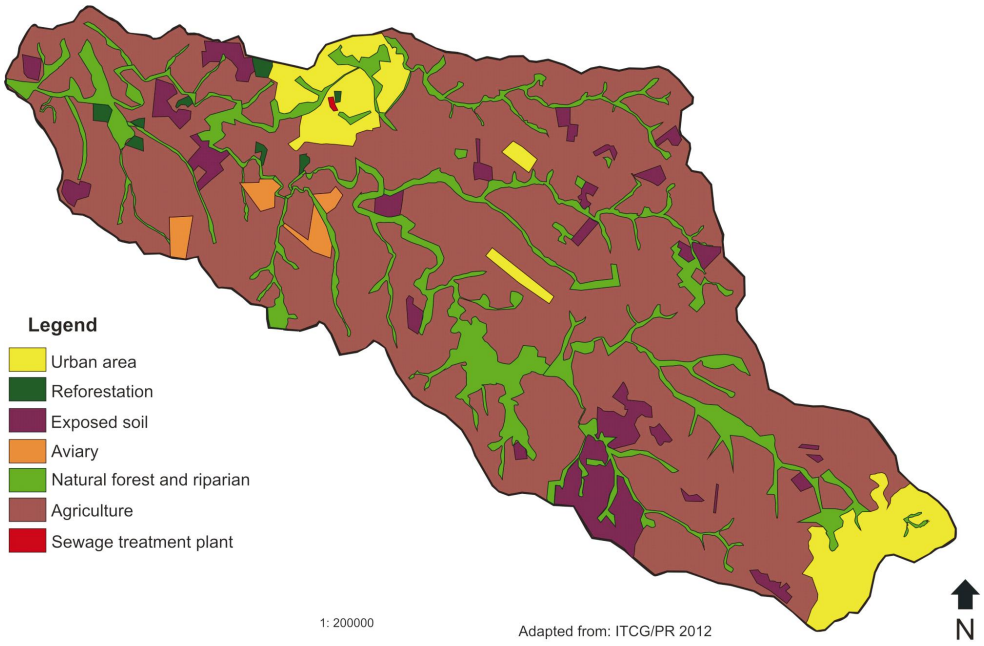

Figure 4. Watershed soil uses in 2012.

This expansion of agriculture and urbanization of the watershed has caused increased sediment yield and changes in streamflow hydrograph. Use changes and land use is generating higher peak flows, which accelerates the erosion of water body receivers. The consequence of these changes is alterations in the concentrations of bottom sediments transported by water flow. In Figure 5, it is possible to observe the increase of flow and sediment concentrations in different years. This alteration is linked by the hydrology alterations due the urbanization process and soil use and generates more energy to transport a greater load of sediments.

The biggest problem of this increase of energy is the increase of capacity to transport more sediments in an area without riparian protection enough. The lack of riparian protection will permit the margin erosion and the increase of sediment concentrations.

Throughout the collection, it can be seen various points of erosion along the body of water, and between the main causes are the lack of riparian vegetation in large parts of the river. This problem can be seen in Figures 6 and 7.

Noting that even where there vegetation, riparian is very narrow and, therefore, it cannot play their role filter runoff, maintaining the temperature of the water place to reduce the loss of oxygen and especially is not capable of controlling soil loss margins, occurring, so the erosion.

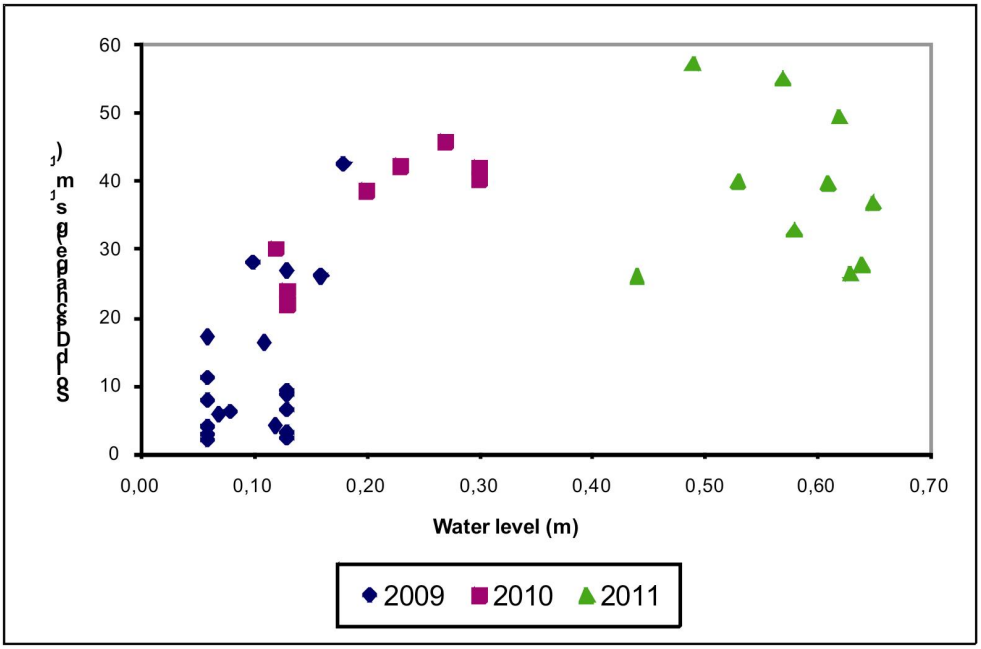

Figure 5. Discharge solid concentration in the years 2009, 2010 and 2011

Figure 6. Excerpts from the river without vegetation near agricultural areas and breeding of animals

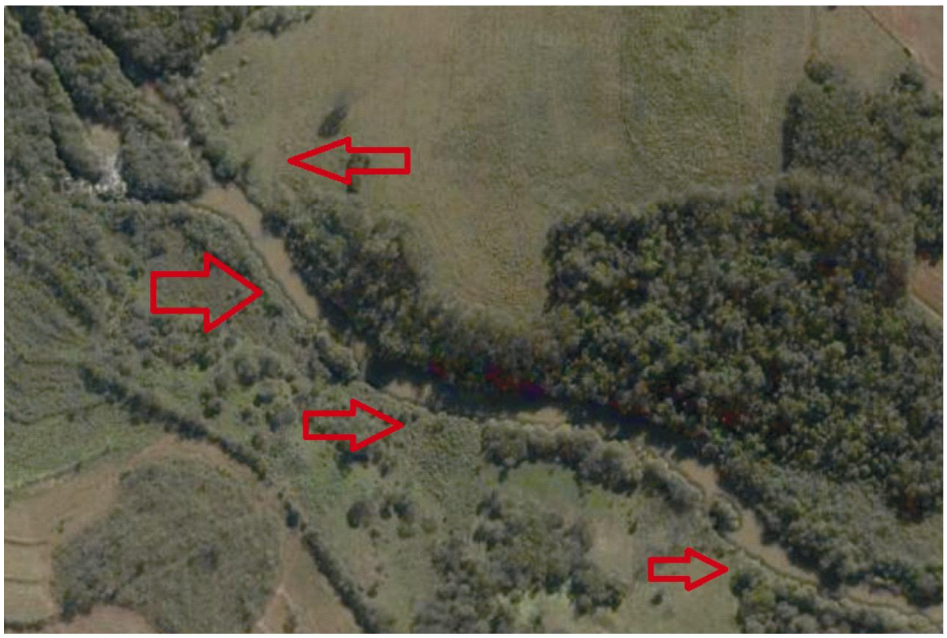

Figure 7. Excerpts from the river without riparian vegetation near the dam

The margin erosions can be observed in Figures 8 and 9. Without the root net formed by the vegetation, the margins become more susceptible to erosion.

Figure 8. Erosion originated by the lack of riparian vegetation

Figure 9. Erosion originated by the lack of riparian vegetation.

With the increase in sediment yield, it is necessary that the natural barriers were able to retain part of the spark, but with current conditions, it is impossible. One consequence is the siltation of lentic water bodies like lakes and reservoirs, as larger particles do not have enough energy to overcome this new obstacle and end up being deposited in the backwater area, as in Figure 10.

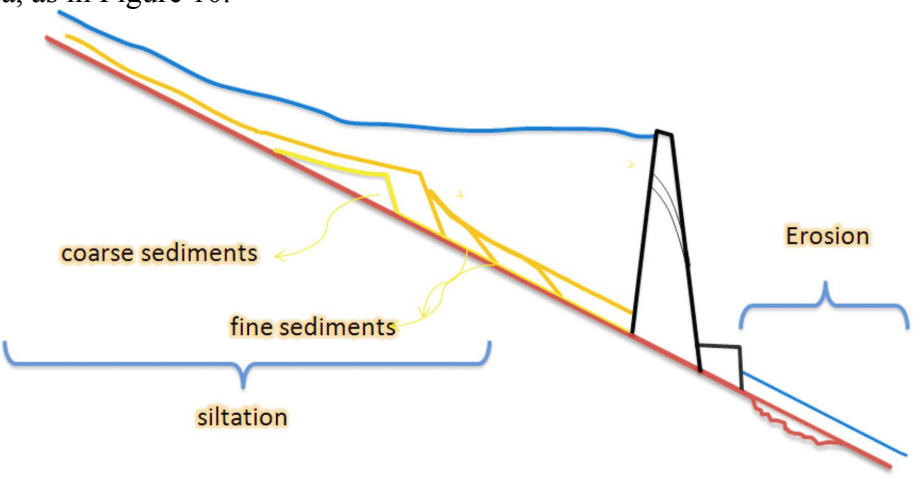

Figure 10. Schematic drawing of the problems of sedimentation and erosion.

There are two cases occurring in a dam: 1) the dam upstream has a reduction of velocity and it start a process of sedimentation that will accelerate its siltation and reducing its useful life, 2) dam downstream has water velocity again and then initiate erosion process due the lack of sediments in the liquid mass.

4 CONCLUSIONS

It can be concluded that changes of use and occupation of land in the watershed generate increased occurrence of peak flow and sediment transport, but the inadequate management of the area (with removal of riparian vegetation and lack of energy sinks in outputs of drainage systems) potentiates the increasing the instability of water bodies morphology. In case of presence of reservoirs, the alterations are worst because they create siltation and erosion process at the same river.

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