QUALITATIVE DIAGNOSIS OF THE INFLUENCE OF SILTING ON URBAN FLOODS

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ABSTRACT: The anthropogenic interventions in the physical environment, exemplified by activities such as the removal of native vegetation, slope cutting and soil sealing, cause changes in the dynamics of land surface processes in a shorter timescale than observed in the natural environment. Alterations in the environment dynamic balance induce the appearance of accelerated erosion and landslides, whose impact is revealed by the deposit of sediments in drainages. As a consequence, the accumulation of sediments compromises river flow, contributing to the occurrence of urban floods and increasing its frequency and intensity. Through a qualitative diagnosis, the present study evidences these facts, demonstrating that studies focused on the prevention and controlling of soil erosion and landslides are essential for urban watersheds conservation planning and flood control.

Key Words: Diagnosis; Erosion; Silting; Urban Flood; Watershed management

1. INTRODUCTION

Since the beginning of agriculture, anthropogenic activities have significantly altered natural processes. The impacts of these activities induced changes in regional hydrology and sediment flux worldwide, directly affecting the frequency and power of floods in these regions (Dotterweich, 2013).

Throughout history, many civilizations have described social, political and economic issues due to floods. In China, for example, historic documents about sediment deposits show the increase of the magnitude and incidence of floods in the Yellow River Basin, during the Tang Dynasty (618 to 907 CE), as a result of rapid sediment aggradation. At that time, the ancient Chinese related the accelerated sediment yield to the degradation of forests, the expansion of farming and associated soil erosion (Dotterweich, 2013).

In fact, most of the impacts of man in the hydrological functions of natural services are related to deforestation and land use and its effects on soil conditions. Some of the consequences of anthropogenic activities are the reduction of soil infiltration and roughness by soil compaction, which increases runoff. As a consequence, it causes dramatic changes to sediment yield (Bruijnzeel, 2004), as stormflow volumes and the peaks are increased, and the discharge capability is reduced by silting of floodplains and the raise of riverbeds (Bruijnzeel, 2004; Yin & Li, 2001).

With the increase in sediment transportation, is expected that silting processes will also be accelerated. As the deposit of sediments occurs majorly in low slope areas, where geomorphology favors silting, the water bodies in such conditions are more likely to have their beds enlarged and raised by aggradation, decreasing the flow capability of the channel (Almeida Filho *et al.*, 2012). This situation of degradation of the natural drainage increases the risk of floods.

Around the world, many places are facing the worsening of flood risks associated with sediment aggradation. The Yellow River remains as an example of this relation, where the riverbed has raised 10 meters above the floodplain and an endless process of levee constructions had to be established (Shu &

Finlayson, 1993). Khalil (1990) related a series of destructive inundations in Bangladesh to heavy alluvial deposit in the rivers' system. Another situation is the one described by Kiss *et al.* (2011) in the Maros River, Hungary, where accelerated overbank accumulation has increased flood risks.

Therefore, the management of flood risks must regard not only hydrological and climatic factors, but also the aspects of soil degradation and erosion. This paper shows, on a qualitative approach, the influence of sediment aggradation to the risk of floods in a small urban basin, evidencing the worsening of floods by changes in the local sediment yield.

2. MATERIALS AND METHODS

In order to evaluate the influence of silting to the occurrence of floods in the urban environment, a small urban basin was chosen, designated as Grama's basin, in the city of Bauru, São Paulo, Brazil (Figure 1).

Figure 1 - Location of the city of Bauru, Brazil.

The city is located at the central portion of the state of São Paulo, where sedimentary rocks prevails. The local geology consists mostly of fine and very fine sandstones, mudstones and siltstones, and rougher sand stones intercalated by parallel layers of fine sandstones and claystones (DAEE/UNESP, 1984). In terms of soil types, according to Oliveira (1999), prevail the pedological associations of red-yellow acrisols and oxisols.

Thus, the area has great tendency to develop water erosion as sedimentary rocks offers less resistance to disaggregation, providing grate amounts of sediments. Also, acrisols have a grains size gradient between the horizons A and B-, which makes them very fragile to superficial runoff. Although this geological condition promotes the development of erosion easily, the morphological aspects lessen the susceptibility because of the less intensive slopes, with the predominance of wide and low hills with convex and flattened tops, with slope varying between 10 and 20% (Ross & Moroz, 1997).

As Grama stream crosses part of the city of Bauru, most of its basin is located in the urban zone, which leads to high rates of soil waterproofing. In addition, part of the stream happens to be rectified, with a pair of avenues located on the natural floodplains, on the channel sides. These situations causes disturbances on both erosion and flood processes.

To state the correlation between the erosion, silting and flood processes in the study area, a qualitative diagnosis was conducted, through a routine of collecting evidences over aerial imagery and field surveys, and by taking interviews with local population.

3. RESULTS

Through photo interpretation of aerial imagery (EMPLASA, 2011), 8 significant gullies were identified, from which 4 were developed in the head of watercourses and the others in the hillslopes. The conditions found at the site, during the field survey (June 2012) are summarized at the following Table 1, followed by pictures of two of the erosions found.

Table 1 – Information about the gullies in the study area

ID	UPSTREAM LAND USE	DOWNSTREAM LAND USE	LIKELY STARTING FACTOR	DIMENSIONS LxWxD (m)	STATUS
ER-001	Urban area in consolidation	Urban area in consolidation	Discharge of urban drainage system	250x30x5	Active
ER-002	Grazing without terraces	Grazing without terraces	Superfical runoff	20x4x3	Active
ER-003	Consolidated urban area	Grazing without terraces	Superfical runoff	60x2x2	Active
ER-004	Consolidated urban area	Grazing without terraces	Discharge of railway drainage system	60x15x10	Partly estabilized
ER-005	Urban area in consolidation	Consolidated urban area	Discharge of urban drainage system	480x20x3	Active
ER-006	Consolidated urban area	Grazing without terraces	Discharge of urban drainage system and sewer	200x50x10	Active
ER-007	Consolidated urban area	Grazing without terraces	Discharge of urban drainage system and sewer	500x8x5	Active
ER-008	Consolidated urban area	Grazing without terraces	Discharge of urban drainage system and sewer	50x10x6	Active

Figure 2 - Erosion ER-004 in June 2012.

Figure 3 - Erosion ER-007 in June 2012.

It is noticed that most of the processes are related to areas with urban use and grazes without soil conservation practices. Also, most of the processes are likely to have been started by irregular discharges, which evidence the lack of appropriate techniques for drainage. The gullies have significant dimensions, up to 10m depth and 500m of extent, and are expected to keep in progress, providing considerable amounts of sediments to the downstream. Along the Grama stream, 7 deposits of sediments were found in the lower areas (such as the one shown at Figure 4).

Figure 4 - Sediment deposit SD-006 in June 2012.

Respecting to the flood issues, the local Civil Defense and the population nearby the stream have reported flood issues at the lower course of Grama. It was observed that the floodplains are occupied, with houses distancing from 10 to 20 meters of the banks. The population had pointed mayor problems in the Comendador Daniel Pacifico Avenue, where a bridge is constraining the water flux, not only by its own structure, but especially by the silting of the stream bed, that reduced the cross section (next to the deposit shown on Figure 6).

The Figure 5 schematizes the processes locations and the referred evidences.

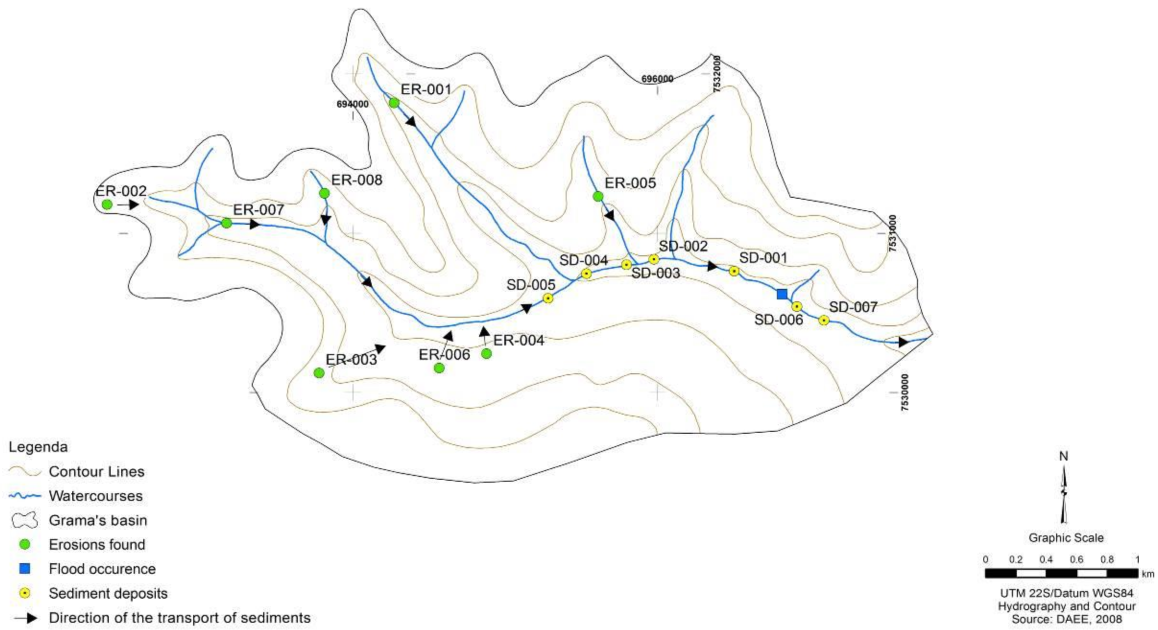

Figure 5 - Scheme of sediment yield, silting and the occurrence of floods in the Grama's basin.

4. DISCUSSION

Over the presented results, it was possible to verify that:

- Due to the geological conditions, the catchment tends to have high sediment yield;
- Due to urbanization, the susceptibility to develop erosion processes was increased, especially by the lack of an appropriate drainage system;
- Large erosive processes has been developed in the area, representing the major contributions to sediment yield;
- As most of the erosive processes in the area are active, it is expected that they will keep on producing sediments;
- Most part of the sediments from the gullies are transported by the watercourses and remains at the lower course of the Grama stream;
- The sediment aggradation is increasingly reducing the capability of flow of the channel, being one of the likely starting factors for floods;
- Floods have been noticed more often in the downstream areas, especially in those near the sediment deposits. Residents relate floods to the channel aggradation;
- The floodplain of the Grama stream is found densely occupied, with avenues right on the borders and buildings close up to 10 meters distance, which increases the risks of flood;

In fact, the combination of geological and land use conditions have created a situation where sediment aggradation is interfering in the occurrence of floods and its risks, what states the influence of silting to urban flood for the Grama’s basin. The management of flood risks in this area must regard not only hydrological and climatic factors, but also the aspects of soil degradation and erosion, considering soil conservation practices and stabilization of the gullies that are already in process.

5. CONCLUSIONS

Although erosion, silting and floods are natural processes, it is in the urban areas that they are severally worsened. Due to the misinterpretation of the environment, inappropriate techniques that disregard interaction between natural factors have led to increase the risks of floods in urban areas. Among these inadequate actions is the lack of concerning of the influence of erosion and siltation to the management of flood risks.

The situation described shows the need of appropriate analyses on sediment yield and silting to subsidize decision making on the management of flood risks. Through a routine of information survey and site examination, it is possible to state relevant relations in a study area by crossing the found evidences to extract logical conclusions.

The study also points the need for quantitative analyses, such as hydrological and hydraulic, concerning the basin and stream, and geotechnical, concerning the erosion process stabilization, and evidences that the management of flood risks must regard the aspects of soil degradation and erosion, considering soil conservation as part of interference on floods regime.

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