The experience on alternative stormwater management techniques in Belo Horizonte - 15 years of a posteriori analysis

L'utilisation des techniques alternatives à Belo Horizonte - 15 années de retour d'expérience

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ABSTRACT

Alternative stormwater management techniques are seen nowadays as one of the most important options for flooding control, mainly to already urbanized areas, where the existing drainage system became inadequate. These structures are based on temporary retention of rainwater and, eventually, infiltration. Although essential in cities and with great possibilities of use and adaptation, these systems cannot be seen as an unquestionable solution to drainage problems. Despite these techniques are currently widely the consequences of the use of such measures has not yet been properly considered. The article presents a posteriori analysis of three examples of this type of technique utilization. The conclusions of this study are that a good planification for the design of systems is essential, as well as consideration of operational difficulties. The adoption of alternative stormwater management techniques for flood control should assume, with fundamental importance, the existence of an appropriate institutional support, ensuring the realization of the project on secure bases of study and ensure the full realization of maintenance procedures. Not observing these conditions may degrade performance of the structure, thus committing a kind of solution that can be extremely useful in many cases.

KEYWORDS

Alternative techniques, Maintenance, Stormwater management, Urban drainage.
1 INTRODUCTION

Urbanization cause significant hydrological impacts, among them we can mention the increase in runoff and reducing in the concentration times, most of them are caused by the increase of impervious areas. As a result of urbanization and drainage piping it is observed the increase of peak flows, as well as the increase in the pollution that reaches the water bodies. Classic drainage systems currently adopted in urban areas are responsible for increasingly floods having important social, economic and political implications.

Alternative stormwater management techniques are seen nowadays as one of the most important options for flooding control, especially to already urbanized areas, where the existing drainage system became inadequate. These structures are based on temporary retention of rainwater and, eventually, infiltration, for flow attenuation, mitigating flooding in the catchment area.

Although essential in cities and with great possibilities of use and adaptation, these systems cannot be seen as an incontestable solution to drainage problems. Despite alternative stormwater management techniques are currently widely used, both in Brazil and in other countries, the consequences of the use of such measures have not yet been properly considered. Planning and meticulous in the design of systems is essential, as well as consideration of operational difficulties, mainly of maintenance and management, that strongly affects environmental quality.

In the alternative stormwater management techniques, much more than in the conventional drainage systems, maintenance has a primary role in their proper functioning. This kind of systems requires more frequent maintenance with procedures different from that the managers are habituated. Guidelines for the maintenance of these techniques exists and they recommend frequent cleaning and sediment removal (CIRIA, 1996; UPRCT, 2004)

The literature relates failures in the alternative stormwater management techniques caused by lack of proper maintenance. The most common problems presented are clogging, vegetation die off, trash collection and the development of mosquito breeding grounds (Barret, 2003; Scoltz, 2004; Hunt et al, 2011; Lord and Hunt, 2008).

Based on the presented context, this article seeks to present, through case studies in Belo Horizonte, a city located in the southeastern region of Brazil, the harmful consequences on the efficiency of alternative stormwater management techniques caused by problems in its design and maintenance operations.

The maintenance of other kinds of alternative stormwater management techniques are also extremely delicate, the need of cleaning the water inlets and outlets very frequently is necessary.

2 OVERVIEW OF THE ALTERNATIVE STORMWATER MANAGEMENT TECHNIQUES INSTALLED IN BELO HORIZONTE

Belo Horizonte is the capital and largest city in the state of Minas Gerais, located in the southeastern region of Brazil. The city is placed it in the tropical zone, the climate classification is tropical savanna climate and it borders on a humid subtropical climate. The mean annual rainfall precipitation is 1500mm.

In Belo Horizonte we have many alternative stormwater systems in operation, several constructed in research context and others constructed aiming to control stormwater in a global scale. Figure 1 shows the location of the techniques in Belo Horizonte.
In the present paper the experiences with the Engenho Nogueira detention basin, the UFMG campus trench and the Lagoa do Nado trenches will be discussed.

2.1 The UFMG Campus trench

The UFMG Campus trench was installed as an experiment, the catchment area is drained by a trench and a swale and they were monitored by Silva.

Despite the experiment find themselves located in the Pampulha campus, the water caught from runoff takes place in a heavy traffic route in the city of Belo Horizonte, Presidente Carlos Luz avenue, which ensures operating conditions of flow control structures similar to the real scale of its use, particularly regarding the aspects of water quality. The predominant soil in the area according to studies conducted by the Belo Horizonte municipality (DRENURBS, 2002), ensure adequate infiltration rates to the employment of infiltration techniques and the local soil hydraulic conductivity was measured through tests with a Guelph permeameter, resulting in average \( 5.21 \times 10^{-5} \) m/s, typical value of silty soils (Silva, 2009).

Geotechnical investigations did not reveal the presence of groundwater in the first 4.0 meters deep, meeting the literature recommendation for the use of infiltration techniques, according to Baptista et al. (2005), a minimum distance of 1.0 meter between the bottom of the infiltration trench and groundwater is required. The slope of the terrain is 4.5%, that value is considered low enough to guarantee adequate volume storage in the system (Silva, 2009).

The experiments installed on the campus of the UFMG receives surface runoff from the Presidente Carlos Luz avenue.
Carlos Luz avenue. The contribution area is 3,880 sqm, of a 4-Lane Avenue, draining towards the North of the city. Runoff generated in this area is drained by ditches to a street inlet, where it is collected and driven to the experiment area. The volume of runoff effectively collected depends on the capture efficiency of the street inlet, which varies with the flow. The collected runoff is diverged in two parts, to supply at the same time, the infiltration trench and the ditch. The Figure 2 shows the catchment area and the infiltration trench.

![Figure 2 - Catchment area and infiltration trench](image)

Silva (2009) had monitored the water level and water quality in the trench and also the parameters of the settled material in the street inlet, which performed as a settling tank. It was observed that less than 20% of the granular material collected in the street inlet has diameter inferior to 0.08mm.

The functioning of the trench was monitored for November 2008 to January 2009, after this period the trench was not maintained. In November 2010 new monitoring procedures were established, after a complete cleaning of the system; the inlet structures were completely filled with sediments.

In this new period of operation, the drainage area, probably by poor maintenance of its pavement as verified in the field, loads a large amount of sediments into the trench, requiring the installation of a grid in the inlet to retain a part of the sediments. With the installation of the grid, the street inlet was constantly filled with sediments, which demanded a cleanup after almost each rainfall event. The effects of these sediments in the trench can be seen in Figure 3 and Figure 4.

![Figure 3 - Sediments in the system (inlet and distribution tube)](image)
The complete clogging of the trench could be observed after less than three months of operation and nowadays the system is completely clogged and non-operative. To reestablish the functioning of the system a complete retrofit will be necessary, a grass layer is preview to catch the coarser sediments.

With this experience the following it could be concluded that even to small catchment route areas it is necessary to have a very well performing sediment catcher, the sediment load observed was much larger than expected.

### 2.2 Lagoa do Nado Park trenches

The area of Lagoa do Nado Park suffer frequently with floods caused by micro drainage insufficiency, in the context of a research project an infiltration trench was installed to drain a small catchment area. Because of lack of land space to install the system, it was constructed under the footpath. The soil conductivity was measured and a mean value of $6.37 \times 10^{-4}$ m/s were observed. The catchment area is constituted of residences and streets, as can be observed in the Figure 5, the figure also shows the construction phase of the trench.
The site was installed in May 2010 and in September 2011 it presented already clogged appearance, as can be seen in the Figure 6. The deposits in the trench surface are specially, as verified by the material texture and odor, due to the organic matter carried to the infiltration trench. Besides the clogged aspect of the trench, severe dysfunctioning was not observed.

Figure 6 - Superficial sediment layer in Lagoa do Nado park infiltration trench (Caputo, 2012)

In 2011 a new infiltration trench was installed near the first one, draining a catchment of 5,000 m². The catchment area consists in residences and streets. In the present case the trench is located in the side of the footpath and it was installed by the municipality to solve local drainage problems. In the Figure 7 photos from the infiltration trench’s construction and its final aspect are exhibited.

Figure 7 - Second Lagoa do Nado Park trench during construction and its final aspect (Caputo, 2012)

From the first storm event problems on the trench appear, a large amount of sediments loads in the trench; a part of the filling material was carried and the geotextile had broken. These damages were caused by the high velocity of the water, the upstream area has large slope, the Figure 8 shows the water velocity during a rainfall event.

Figure 8 - Functioning of the trench during a rainfall event (Caputo, 2012)
The filling material was carried to the conventional drainage system committing the drainage of the area (Figure 9).

![Figure 9 - Filling material spread for the water (Caputo, 2012)](image)

### 2.3 The Engenho Nogueira detention basin

The Campus of the Federal University of Minas Gerais, located in Belo Horizonte suffered from frequent flooding problems, macro-drainage system overflows six times per year on average, with low submergence depths (usually less than 50 cm). To resolve this problem on a local scale and to attenuate floods in more global scale, the Municipal Administration and the University decided to deploy a detention basin.

The Engenho Nogueira detention basin receives the runoff of a dense urbanized area of 3 km². The detention basin consists of a dam in earth and rock and has a bottom discharge which allows the passage of water from the watercourse during periods of drought. In raining periods the bottom discharge controls the output flow and the accumulation of water in the reservoir occurs.

Feasibility studies and choice of deployment scenarios defined a detention basin a basin with 328,000 m³ of detention volume, designed to absorb rainfall events of return periods of up to 50 years without the occurrence of emergency overflow.

However, at the time of its construction, it was decided to deploy a basin with a volume smaller than the originally planned, 83,600 m³, occupying an area of about 22,000 m². The Figure 10 shows photographs of the detention basin.

![Figure 10 - Engenho Nogueira’s detention basin under construction and during a stormwater event (Fausto Parsia)](image)

After a year of the detention basin operation, another sort of problem arose due to lack of proper maintenance of the system. Part of the sewage and industrial effluents coming from companies
located in the catchment were still thrown into the stream, which caused significant contamination of its waters. A large accumulation of sediment on the bottom of the basin and partial obstruction of bottom discharge, caused by deficiencies in solid waste collection and proper maintenance of the detention basin, were observed. The Figure 11 shows the evolution of the sediments accumulation on the bottom of the basin.

![Image of sediments accumulation](image1.png)

Figure 11 - Sediments accumulation in the detention basin bottom discharge - November 2010, March 2011 and October 2011

On the exit of the bottom discharge waste accumulation was observed, as shown in the Figure 12.

![Image of waste accumulation](image2.png)

Figure 12 - Waste accumulation in the exit of the bottom discharge
To quantify the effects of the problems presented previously in the functioning of the detention basin a modelling was performed – Moura et al. (2012) – and allowed the estimation of return periods of rainfall that do not cause operation of the detention basin emergency overflow. They are: 50 years for the projected basin, about 3 years for the basin effectively deployed, dropping to 2 years on the situation after one year of operation.

Thus, the detention basin does not meet completely its role, protecting University campus only from rainfall events with small return periods, a fact exacerbated by the lack of proper maintenance, which reduces protection for precipitations with return period of less than 2 years.

3 CONCLUSIONS

The related problems that occurred in some Belo Horizonte’s alternative stormwater management techniques show that the problem of planning, operation and maintenance can be often quite critical, allowing us to discern some essential points, and significant to all the alternative stormwater management techniques in urban areas. It is important to clarify that there are many successful alternative stormwater management techniques in Belo Horizonte, but the feedback of the problematic experiences allows the improvement of the issues of the usage to this kind of system.

First we must not conceive alternative stormwater management techniques as a solution to all types of drainage problems; they require a significant investment, not only for deployment, but for operation and maintenance, under penalty of loss of efficiency.

The issues raised regarding the operation of existing sites are relevant since they indicate the need for prevention and protection against the sediments load or even the necessity of establishment of pre-treatment and cleaning routines, particularly when the drainage area can provide major contribution of sediments. The experiences could also indicate to avoid using source control structures in areas with high slope, where the water arrives on high speeds compromising the drainage structures.

A second aspect to highlight is the consequences of inadequate operation and maintenance may be reflected by significant environmental, social and financial costs. In presented examples there was commitment of the environment, caused by the accumulation of garbage, sewage and growth of plants in the reservoir, clogging in the trenches and odor problems.

It can be concluded that the adoption of alternative stormwater management techniques for flood control should assume, with fundamental importance, the existence of an appropriate institutional support, ensuring the realization of the project on secure bases of study and ensure the full realisation of maintenance procedures. Not observing this conditions may degrade performance of the structure, thus committing a kind of solution that can be extremely useful in many cases.

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LIST OF REFERENCES


