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## **Challenges for the sustainable urban stormwater management in developing countries : from basic education to technical and institutional issues**

Défis pour la gestion durable des eaux pluviales urbaines dans les pays en développement : de l'éducation basique aux questions techniques et institutionnelles

Joel A. Goldenfum\*, Rutinéia Tassi\*\*, Adalberto Meller\*, Daniel G. Allasia\*, André L. da Silveira\*

\* IPH – UFRGS - Av. Bento Gonçalves 9500 - C.P. 15029  
91501-970 - Porto Alegre - RS – BRAZIL

\*\*FURG - SHS - Dep. Física - Av. Itália km8/sn - Rio Grande - RS – BRAZIL  
[j.goldenfum@gmail.com](mailto:j.goldenfum@gmail.com); [rutineia@gmail.com](mailto:rutineia@gmail.com); [betomeller@uol.com.br](mailto:betomeller@uol.com.br);  
[hidrologia@gmx.net](mailto:hidrologia@gmx.net); [andre@iph.ufrgs.br](mailto:andre@iph.ufrgs.br)

### **RESUME**

Les défis pour une gestion durable des eaux pluviales urbaines dans les pays en développement sont considérables par rapport aux pays développés. Cet article utilise l'exemple de la ville de Porto Alegre pour analyser cette situation. Les principales difficultés sont dues à deux aspects généraux : le niveau inégal de connaissance parmi les plusieurs acteurs de la gestion urbaine (y compris données insuffisantes, l'information technique déficiente et la manque d'une véritable éducation environnementale pour les législateurs, les décideurs et le grand public); et l'inexistence d'une adéquate structure institutionnelle (l'action non intégrée des différents secteurs de gestion urbaine peuvent conduire à des problèmes d'inondation et pollution, dont les coûts sont payés par la municipalité). Pour changer cette situation sont donc proposées des actions pratiques ciblées dans l'amélioration des relations institutionnelles et la diffusion de la connaissance.

### **ABSTRACT**

The challenges for the sustainable urban storm-water management in developing countries are considerable. This paper takes the city of Porto Alegre, in Brazil, as a case study to analyse this situation. The main identified difficulties are due to two general aspects: a bad balance of knowledge among the many involved actors (including data deficiency, weak technical information and lack of a real environmental education for legislators, decision makers and the general public); and the inexistence of adequate institutional arrangements (a lack of integrated action among the different sectors results in inundation problems and pollution, with costs paid by the public sector). The proposals to change this scenario are centered in practical actions aiming institutional improvements and knowledge transfer.

### **KEYWORDS**

Compensatory devices, environmental educational, institutional arrangements, sustainable stormwater management, urban drainage master plans.

## 1 INTRODUCTION

Sustainability is already recognized as a very important concept for the urban drainage management. There are, however, many difficulties to effectively implement a sustainable urban stormwater approach in developing countries (Silveira et al., 2001; Silveira and Goldenfum, 2004).

Urban drainage control measures include a series of different aspects, ranging from technical engineering solutions, architectural design, and legal and economic questions. Each of these subjects has to be considered in an integrated view, together with the others, so that the adopted measures can produce the desired results. In developing countries, the climatic and socioeconomic conditions bring difficulties to the use of solutions adopted in temperate areas. Problems such as greater capacity to generate runoff, greater erosive capacity, favorable conditions for the proliferation of vectors or carriers of tropical diseases, allied to uncontrolled urban expansion, precarious public works cleaning and inspection services, besides technically outdated and ill-planned storm drainage systems can complicate, and even make not feasible, the use of some devices and structures already in use elsewhere (Silveira et al., 2001).

While the developed countries are concerned with problems related to diffused pollution on the pluvial waters, developing countries such as Ethiopia (Abeje, 2004), Turkey (Yilmaz, 2004), India (Rahman, 2004) and Iran (Motiee, 2004) still present low coverage on drinking water and sewerage networks, and precarious urban drainage infrastructure. The existing urban drainage systems become inefficient face to the rapid expansion of the towns and cities, and the usual practice to control urban drainage is the rapid outflow of excess stormwater by open channels and buried conduits, usually mixed to the sewage. Sediments and solid waste bring more complexity to this situation, contributing to the dissemination of diseases to the population, as commented by Rahman (2004). According to Silveira et al. (2001), the use of technical solutions aiming to control runoff generation at its source is, in general, at initial stages of research and development, being seldom applied neither in public nor in private works. Also, there are few resources for infrastructure implementation (Yilmaz, 2004; Rahman, 2004) and a weak optimization of these resources, as result of a bad management, where each sector develops its actions separately and with no integration with other areas, as related by Abeje (2004).

Several structural or non-structural control measures could be adapted to climatic and socioeconomic conditions in an integrated view, together with the environmental planning of urban areas, putting together all aspects involved. The development of Urban Drainage Master Plans and the implementation of compensatory techniques could be valid instruments to tackle these limitations. However, these solutions face many obstacles such as: data deficiency, uncontrolled urban expansion, lack of legal instruments, lack of knowledge and technical information on infiltration and storage devices, and water quality problems. All these problems bring resistance from designers, public managers and the population to the implementation of distributed and on-site flow control devices.

Brazil is no exception in this scenario. However, some awareness on this problem has already been developed, and some cities already show results of the application of sustainable concepts in urban drainage management. A good example is the city of Porto Alegre, the capital of the state of Rio Grande do Sul. Among all the Brazilian state capitals, only Porto Alegre has a municipal department that deals specifically with urban drainage issues: the DEP (Department of Storm Drainage Systems), which was created in 1973. There is also a strong research tradition in the urban drainage field, mainly through the initiative of the IPH (Institute of Hydraulic Research of the

Federal University of Rio Grande do Sul). By actions of DEP and IPH, Porto Alegre was the first Brazilian city to develop an Urban Drainage Master Plan. As a result of this planning, several source and distributed runoff control facilities have been already built in the city and many others are being constructed. However, even in Porto Alegre most of the problems already reported in other developing countries can be easily identified.

The present paper aims to identify and to describe these limitations and to point out for possible solutions to overcome these difficulties, in order to reduce the restrictions to the implementation of urban stormwater sustainable management in developing countries, taking the city of Porto Alegre, in Brazil, as a case study.

## **2 DIFFICULTIES FOR THE DEVELOPMENT OF URBAN DRAINAGE MASTER PLANS**

The success of the development and implementation of an Urban Drainage Master plan is very much dependent on the adaptation of well-known urban drainage principles to each city's reality. During this adaptation process, the technicians face institutional, legal, social, financial and even cultural restrictions to the implementation of innovative alternatives.

The recent experience on the development of an Urban Drainage Master Plan for the city of Porto Alegre showed that this activity in developing countries such as Brazil is limited by problems such as the lack of appropriate data and the uncontrolled urban expansion.

### **2.1 Lack of hydraulic and hydrological related data**

Urban Drainage Master Plans development demands the determination of the existing drainage network hydraulic capacity. Only a few cities in Brazil have a proper record of the drainage network. Hydrological gauging data networks are also uncommon, being very difficult to find hydrological data such as measured water flow in natural and built drainage paths. In this scenario, the designers are frequently compelled to use indirect modelling calibration processes, such as the use of inundation marks.

In Porto Alegre, only a few of the most important water courses present flow gauging stations, and the records are frequently discontinued. The great majority of the urban rivers and creeks are not monitored, bringing difficulty for the flow estimation.

There are four different IDF curves in Porto Alegre. Although they are not evenly distributed in order to properly represent the different characteristics of the rainfall in Porto Alegre, these curves show that there is a great spatial variability in the rainfall distribution in the city limits. In this way they are very helpful to bring bigger reliability to the structures design. This situation, however, is not common in the majority of the Brazilian cities, so that the rainfall characteristics frequently have to be obtained by data from other neighbouring regions.

Only a limited number of cities in Brazil present a record of the existing drainage network. Even in the cities where this record is available, such as Porto Alegre, it presents several restrictions:

- the creeks where no works have been done are not included in the records, and, during the studies for the development of the Urban Drainage master Plan, topographic studies were necessary to estimate its hydraulic characteristics;
- many inconsistencies were observed between the records and the real field situation, mainly due to lack of records updating, constructive problems that led to design modification during construction, bad conservation state of old drainage networks, and obstructions due to several interferences (figure 1).



Figure 1 – Interferences and abstractions in drainage networks (IPH, 2004)

## 2.2 Uncontrolled urban expansion

The determination of flow limits for future occupation scenarios is not an easy task, due to the difficulty to forecast permeability soil rates. Although many cities already have land occupation rules, there are many areas with informal occupation that does not follow these regulations. Residences located by creeks margins with direct sewage emissions to the water body are frequently found (figure 2).



Figure 2 - Residence by creeks margins with direct sewage to the water body

The Urban and Environmental Master Plans present the main occupation rules and strategies for the cities. In Brazil, according to a recent law (Estatuto das Cidades, 2001), all cities and towns bigger than 20.000 people have to develop and update an Urban and Environmental Master Plan. However, only a few cities already finished the development of these Master Plans and can present a proper planning for the city occupation and development. Also, the existence of these master Plans does not ensure that they will be properly enforced. In all Brazilian cities there are many areas where the occupation does not follow the existing rules, and the densification and

growing trends are frequently very different from what was planned, bringing difficulties to forecast the real figures of the land use and occupation in the future.

The hydrological modelling is dependable of parameters related to the soil use and occupation. The lack of reliability on the characterization of future occupation scenarios brings great uncertainty for the prediction of stormwater flow values and, consequently, for the definition of regulations and control devices dimensions.

### **3 DIFFICULTIES FOR THE IMPLEMENTATION OF DISTRIBUTED AND ON-SITE FLOW CONTROL DEVICES**

The development of urban stormwater sustainable systems implies the adoption of compensatory devices (Silveira and Goldenfum, 2004). The Urban Drainage Master Plans frequently suggest the adoption of such devices as a way to control the flow excess and keep it under the maximum acceptable limits. However, the design and implementation of these devices in developing countries frequently faces opposition.

Traditionally, the approach to tackle drainage urban problems in developing countries is based on the hygienist principle, trying to transfer the water as quick as possible out from the inundated areas. The use of compensatory devices was introduced during the 1990 decade, mainly adopting detention basins. There is already good experience about the use of detention basins in some Brazilian cities, but there is still great opposition from the majority of the designers to the adoption of these devices, mainly because of lack of knowledge and technical information on infiltration and storage devices and due to the natural resistance to new concepts and ideas (Baptista et al., 2005).

Also, problems due to water quality issues, bad design and execution, lack of appropriate spaces, besides political and institutional problems, frequently cause malfunctioning to the devices, bringing lack of confidence to the population on the use of these systems.

#### **3.1 Water quality issues**

The quantitative control is usually preponderant over quality control in urban drainage in Brazil. This is mainly consequence of the urgency to solve important flooding problems, where the first concern is to reduce the inundations (Silveira and Goldenfum, 2004). Problems such as illegal connections of sewage into the separate drainage network, and great amounts of sediments and organic matter decrease the performance of these structures, due to the pollution, proliferation of disease vectors and reduction of the storage capacity.

An example of this situation is the "Parque Marinha do Brasil" retention reservoir built in Porto Alegre. This device was designed to receive only pluvial waters. However, after its construction, big amounts of sewage contributions were identified, mainly due to clandestine connections, not identified in the existing records. In other structures, great amounts of solid waste can be found after intense rainfall events (figure 3).

#### **3.2 Bad design and execution**

Frequent design and execution problems are observed in the Brazilian experience with compensatory devices. Some issues, typical to developing countries, bring complexity to the structures conception and maintenance. For example, the big amount of sediments, litter and debris by the drainage network demands frequent maintenance of the structures, which contrasts with the reduced budget of the public sectors. The use of traditional design techniques for detention basins results in low performance of the devices and high maintenance and rehabilitation costs (Nascimento et al., 1999).



Figure 3 – Solid waste in a detention reservoir (Orsini, 2001)

### **3.3 Lack of legal instruments and difficulty to approve new legislation**

Only a few cities in Brazil present legal instruments to regulate the use of compensatory devices. In the majority of the cases, the costs to prevent and solve inundation problems are paid by the public sector, even if they are caused by private developments. Consequently, there is strong opposition from developers to change this situation.

In Porto Alegre, there is a law proposal to regulate and impose the construction of compensatory devices in order to keep the stormwater under a maximum limit. This proposal was presented with the Urban Drainage Master Plan, in the year 2000, but, until now it has not succeeded to be approved, due to developers' pressures.

### **3.4 Urban planning restrictions**

One of the major restrictions for the implementation of compensatory devices is the lack of appropriate public or private spaces. The plans that regulate soil use and occupation often do not reserve urban spaces for this use, and the availability of adequate areas to execute these devices is very low in already developed areas, severely increasing the costs.

### **3.5 Institutional and political problems**

In the majority of the cities in developing countries there is not enough articulation among the several public organs that deal with questions related to the water in the urban environment. Many of the internal policies of these departments do not favour decisions important to the adoption of compensatory devices. For example, the use of public parks areas as detention basins is frequently not allowed by the environmental organ, due to possible contamination by sewage. Also, there is lack of public funds to keep and maintain these structures.

In Porto Alegre, there is no agreement among the environmental department (SMAM), the urban drainage department (DEP) and the urban cleaning department (DMLU) on the use of public parks areas as open detention reservoirs. SMAM does not allow the use of these areas because of the pollution due to mixed sewages, DEP has not enough personal to guarantee their maintenance after strong rainfall events,

and DMLU cannot afford the extra task of doing this maintenance. Also, there is no legal support to guarantee that a private company could do this work properly in a long term basis.

Another problem is caused by discontinuities in public policies after changes in the local government. Very frequently, when there is a change of local government, the practices taken by the previous government are questioned. The adoption and maintenance of compensatory devices is a public policy that is often discontinued, mainly due to lack of knowledge of public managers, even in cities like Porto Alegre, where there is already awareness among the technical staff on the importance of these devices.

### **3.6 Opposition by the population, designers and public managers**

All the difficulties described above, combined with the lack of information of the population, frequently bring strong opposition to the use of compensatory devices.

In the case of detention basins, when the maintenance is not adequate, the high load of organic matter, sediments and litter creates an inadequate environment. The population fears the contamination and also the devaluation of their properties. This entire situation constitutes a bad example of use, reinforcing opinions against the use of these solutions.

## **4 PROPOSED SOLUTIONS**

These difficulties for the adoption of a sustainable approach for the Urban Stormwater Management in developing countries can be overcome by a series of simple measures, ranging from educational to institutional issues.

A series of administrative actions has to be taken, in order to promote a real institutional integration among the several administrative organs in the cities, aiming to favour the adoption of compensatory devices for urban drainage control. Long-term planning should be privileged, by the development of appropriate Urban Drainage Master Plans and by the implementation of laws and real conditions to enforce the adoption and proper maintenance of compensatory devices.

In terms of education, it is necessary to favour the knowledge transfer, at different levels:

- technical information to the designers, in order to allow the elaboration of adequate projects;
- general information to legislators and decision makers, in order to inform about the existence of other solutions than the simple transference of the inundations;
- and environmental education to the general public, in order to make clear the importance of the sustainable approach.

The academia plays an important role in this aspect. In this way, experimental studies are already being used to present demonstrative effects of the advantages of the sustainable approach. Also, educational campaigns are being developed in Porto Alegre, where various sectors of the University work together to inform the population on the advantages of the use of stormwater quantitative and qualitative control.

## **5 CONCLUSIONS**

The adoption of a sustainable approach for the Urban Stormwater Management faces many difficulties in developing countries, mainly due to data deficiency, uncontrolled urban expansion, lack of legal instruments, lack of knowledge and technical



information on infiltration and storage devices, and water quality problems. These problems can be tackled by a combination of educational and administrative actions, in order to promote institutional integration and to transfer knowledge from the research sector to the population.

This paper presented some problems faced during the Urban Drainage Master Plan development and implementation in Porto Alegre, Brazil. During the Urban Drainage Master Plan elaboration, difficulties due to lack of hydrologic data, proper drainage network records and difficulties for urban occupation forecast were identified. During its implementation, the population showed rejection to the adoption of detention ponds, due to bad experiences, mainly related to the presence of clandestine sewage connections, solid waste, sediments and lack of appropriate maintenance. Also, the pressure from developers slow down the approval process of laws to reinforce the use of source control devices.

Although the academia has been promoting actions to inform technicians and public administrators about the importance of the use of compensatory devices, there is still the need of more information for the population, so that these actors can understand their roles for a sustainable urban drainage management.

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## LIST OF REFERENCES

- ABEJE, W. (2004). Urban Water Observatory for Addis Ababa: Integrated Planning and Management Instrument. In: Proceedings of the 5th Novatech conference on Innovative Technologies in Urban Storm Drainage, p.1329-1324, GRAIE, Lyon, June 6-10, 2004.
- BATISTA, B.B.; NASCIMENTO, N.O.; BARRAUD, S. (2005) Técnicas Compensatórias em Drenagem Urbana. Porto Alegre: ABRH, 266p.
- ESTATUTO DAS CIDADES (2001). Lei no 10.257 de 10 de Julho de 2001. Presidência da República - Brazil.
- IPH (2002). Instituto de Pesquisas Hidráulicas da UFRGS - Photography Collection. Photography taken at Passo das Pedras Creek. Porto Alegre, Brazil. June 2002.
- IPH (2004). Instituto de Pesquisas Hidráulicas da UFRGS - Photography Collection. Photography taken at Dilúvio Creek. Porto Alegre, Brazil. May 2004.
- IPH (2004). Instituto de Pesquisas Hidráulicas da UFRGS - Photography Collection. Photography taken at Marinha do Brasil retention reservoir. Porto Alegre, Brazil. February 2004.
- MOTIEE, H.; KHORSANDI, A.; YAZDI, A.S. & MOTIEI, F.M. (2004). Necessity of Storm Water Drainages due to rapid extension of big cities. Case study: Storm Water Drainage of Tehran. In: Proceedings of the 5th Novatech conference on Innovative Technologies in Urban Storm Drainage, p.1351-1358, GRAIE, Lyon, June 6-10, 2004.
- NASCIMENTO, N. O.; ELLIS, J. B.; BAPTISTA, M. B.; DEUTSCH, J.C. (1999) Using detention basins: operational experience and lessons. *Urban Water*, v.1, issue 2, p.113-124.
- ORSINI, L. F. (2001). Photography taken at "Piscinão" in São Paulo, Brazil. 2001.
- RAHMAN, A. (2004). The state of urban drainage conditions and management in Aligarh city, India. In: Proceedings of the 5th Novatech conference on Innovative Technologies in Urban Storm Drainage, p.1303-1310, GRAIE, Lyon, June 6-10, 2004.
- SILVEIRA, A. L. L., GOLDENFUM, J. A., FENDRICH, R. (2001) Urban drainage control measures. In: *Urban drainage in humid tropics*. Paris: Unesco. p.125-156
- SILVEIRA, A. L. L.; GOLDENFUM, J. A. (2004) Sustainable approach applied for the development of urban drainage manuals in Brazil In: *Novatech 2004*, 2004, Lyon - França. Novatech 2004. Lyon - França: GRAIE. v.2. p.1325 – 1332.
- YILMAZ, L. (2004). The Determination of master drainage plans and the reclamation of stormwater in developing countries. In: Proceedings of the 5th Novatech conference on Innovative Technologies in Urban Storm Drainage, p.1365-1368, GRAIE, Lyon, June 6-10, 2004.