BENEFITS OF BEST MANAGEMENT PRACTICE MEASURES IN FLOOD MANAGEMENT

AVANTAGES DES MEILLEURES PRATIQUES DE GESTION DANS LA GESTION DES INONDATIONS

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ABSTRACT

Infrastructure and agricultural production are extensively damaged by extreme flooding in many countries. Many international aids are involved in the short-term problems due to excessive floods. Instead, long term solutions and investments are required to get more durable protection of agricultural lands and infrastructure.

BMP (Best Management Practice) is a holistic approach that aims to minimise negative impacts on the natural water cycle and protect the health of aquatic ecosystems. Among the BMP key principles are to protect existing natural features and ecological processes, to maintain the natural hydrologic behaviour of catchments and to preserve the quality of surface and ground waters. Although BMP are mainly employed in the design of urban development, resort to this kind of measure is possible also in agricultural lands.

In this work the concept of BMP was applied to the experimental catchment of Mostacciano in Rome, Italy. To perform the analysis the software SWMM 5.0 (Storm Water Management Model) was used. The model was calibrated by available rainfall and discharge data. Different scenarios were built and evaluated in terms of flood peak and volume reduction.

Key words: *Best management practices, Flood management, SWMM model, Mostacciano experimental catchment (Italy).*

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RESUME ET CONCLUSIONS

Les infrastructures et les productions agricoles sont très endommagées à cause des inondations extrêmes dans de nombreux pays. Les aides internationales sont employées pour résoudre les problèmes à court terme qui suivent les inondations excessives. Alors que, des solutions à long terme et des investissements sont nécessaires pour obtenir protections plus durables des terres agricoles et des infrastructures. Une bonne programmation est nécessaire pour mesurer l'efficacité des investissements contre les inondations et pour offrir une base pour identifier la meilleure stratégie pour assurer une gestion réussie de l'eau.

BMP (Best Management Practice) est une approche holistique qui vise à minimiser les impacts négatifs sur le cycle naturel de l'eau et protéger la santé des écosystèmes aquatiques. Un grand niveau de conscience et de compréhension est nécessaire pour augmenter l'acceptation et l'application du BMP.

Les points clés du BMP sont:

- *réduire la crête de ruissellement des flux, en développant la capacité de stockage du site (pour la réutilisation) et réduire les zones imperméables;*
- *défendre les systèmes naturels (ruisseaux, fleuves et zones humides);*
- *protéger la qualité de l'eau en améliorant la qualité des eaux de ruissellement;*
- *intégrer le traitement des eaux pluviales dans le paysage en utilisant des systèmes de traitement des eaux pluviales. Ces systèmes peuvent avoir plusieurs usages fournissant une variété de prestations, comme par exemple le traitement de la qualité de l'eau et des habitats fauniques;*
- *ajouter de la valeur à long terme en minimisant les coûts de développement;*
- *réduire la demande en eau potable en utilisant des eaux pluviales comme une ressource pour la réutilisation à des finalités non-potable.*

Dans ce travail, une application du BMP a été effectué au bassin expérimental de Mostacciano qui se trouve prés de Rome, en Italie. Les mesures examinées du BMP sont les Bassins d'infiltration et l'eau de pluie des réservoirs.

Les bassins d'infiltration peuvent être placé dans zones ouvertes naturelles ou artificielles, conçues pour retenir temporairement les eaux de ruissellement avant de s'infiltrer à travers le plancher du bassin.

Les réservoirs d'eau de pluie sont des réservoirs destinés à contenir l'eau de pluie recueilli par les toits.

Le software SWMM 5.0 (Storm Water Management Model) a été utilisé pour effectuer les analyses.

Le bassin versant est divisé en 7 sous-bassins, chacun étant caractérisé par distinctes paramètres hydrauliques, géomorphologiques et topographiques. Les mesures du BMP sont représentées dans le modèle comme sous-bassins, paramétrés de manière différente en fonction de leur comportement hydraulique. Le modèle est calibré par les précipitations *et par les mesures de la décharge disponible. 11 scénarios sont construits, en simulant différentes conditions de saturation du sol et du pourcentage de la superficie d'application.*

Les résultats sont évalués en termes de pointe de crue et de réduction des volumes à travers des indices statistiques.

L'étude a souligné que l'utilisation du BMP a réduit le volume et le pic de crue. En particulier, les réductions les plus importantes ont été obtenu lorsque les mesures ont été effectué en même temps. Dans ce cas les degrés de saturation élevés n'ont pas influencé la bonne réussite des mesures du BMP.

Mots clés : *Meilleures pratiques de gestion, gestion des inondations, modèle SWMM, bassin expérimental de Mostacciano (Italie).*

(Traduction française telle que fournie par les auteurs)

1. INTRODUCTION

The key principles of BMP (Argue, 2004, Institution of Engineers 2001) are:

- To reduce runoff peak flows from developments by on-site temporary storage measures (with potential for reuse) and minimise impervious areas;
- To defend natural systems (creeks, rivers and wetlands);
- To protect water quality by improving the quality of storm water runoff;
- To integrate storm water treatment into the landscape by using suitable treatment systems that incorporate multiple uses providing a variety of benefits such as water quality treatment and wildlife habitat;
- To add long-term value while minimising development costs; and
- To meet potable water demand from other available water by using captured storm water for non-potable purposes.

In this work BMP was applied to the experimental catchment of Mostacciano in Rome Italy. The examined BMP measures are the infiltration basins (Jonasson 1984) and the rainwater collection tanks (Coombes and Kuczera 2003).

To perform the analysis the software SWMM 5.0 (Storm Water Management Model) is used. The catchment is divided in 7 subbasins, each characterized by distinct hydraulic, geomorphologic and topographic parameters.

2. CASE STUDY

2.1 Mostacciano experimental catchment

Mostacciano experimental catchment belongs to the Italian National Research Council – Istituto di ricerca sulle Acque, and is localized in the South-West part of Rome. The basin area is 0.15 km^2, constituted by impervious area for the 65%, and by pervious area for the rest.

The basin boundary was evaluated by GPS survey. Table 1 shows main geomorphological characteristics of the basin. The basin has high slope.

Table 1. Geomorphological characteristics of the study area (les caractéristiques géomorphologiques de la zone d'étude)

Area	A [km²]	0.15
Perimeter	P [m]	1810
Main river length	L [m]	853
Mean altitude	H [m a.s.l.]	36.27
Maximum height difference	ΔH [m]	33.60
Slope	i [%]	4.88

Figure 1 represents the study area, with drainage network, the outlet section and the boundary of the experimental catchments evaluated by the GPS points.

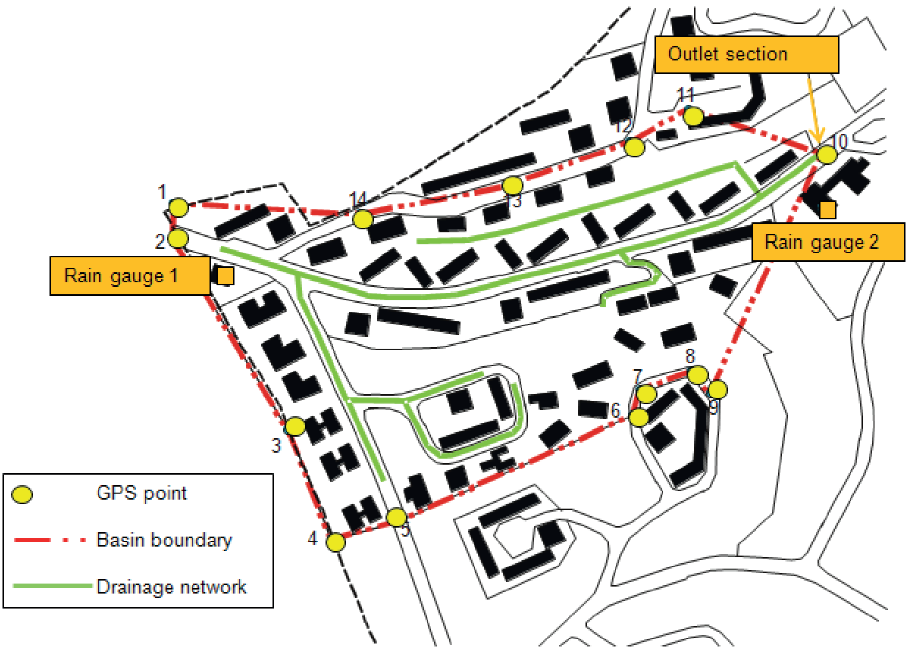

Fig. 1. Mostacciano experimental catchment. (Le bassin expérimental Mostacciano)

Basin geolithology icomprises sand-clay deposits, volcanic rocks and alluvial terrains. Hydrogeology circulation of the study area is of low entity.

The measurement network has 2 raingauges, with 1 minute time resolution and one hydrometer located in the outlet section of the basin. Water stage was measured at 1 hour interval in dry condition and at 1 minute interval in wet periods to evaluate carefully the flood hydrograph behaviour.

In order to evaluate the BPM performance the basin and the management measures studied are represented by the SWMM model. The drainage network was known through previous experimental analysis. It is assumed that during the flood events the waste water contribution, caused by resident population (4.5 persons/km2 density), is negligible.

The examined area was subdivided in seven subbasins, assigning to each the nearest raingauge, weighted by Thiessen method.

Fig. 2 represents the SWMM basin model, divided in the seven subbasins and drainage network schematization.

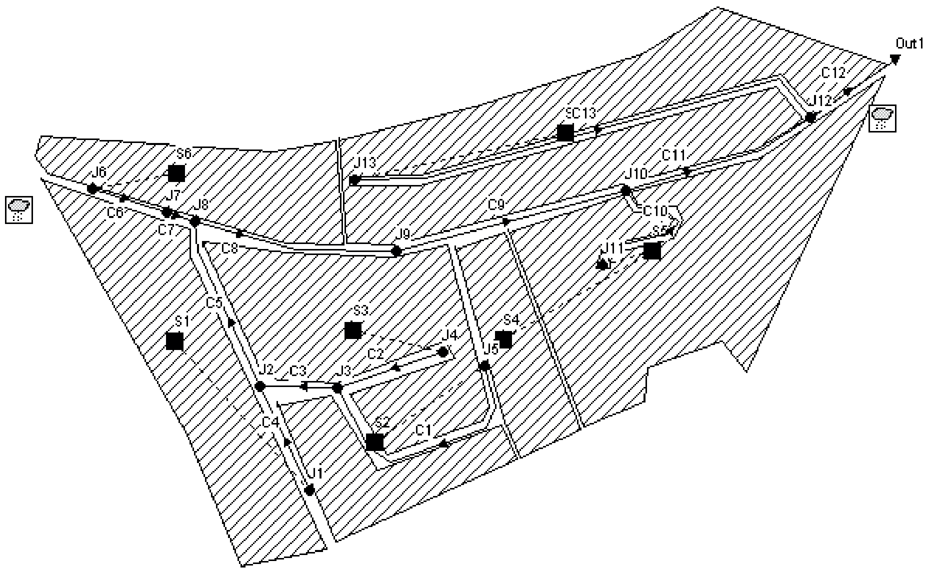

Fig. 2. SWWM model of Mostacciano basin. S_i square represents subbasins, J_i represents the inlet points in the drainage network, C_i represents the pipe sections and Out1 is the outlet section (Le modèle SWMM du bassin Mostacciano. Les S_i carrés représentent les sous-bassins, les J_i représentent les points d'entrée dans le réseau de drainage, les C_i représentent les sections de tuyaux et OUT1 est la section de sortie)

2.2 Infiltration basins

Infiltration basins can be located either in natural or man-made open areas, designed to temporarily hold storm water runoff for infiltrating through the basin floor.

The main functions of infiltration basins are: (a) Removing pollutants; (b) Reducing runoff volumes; (c) Delaying runoff peaks by providing detention storage capacity and reducing flow velocities.

Infiltration basins may be small or large. Usually small scale units (catchment area <5 ha) are excavated pits or ponds, while larger scale units (catchment area up to 50 ha) are the natural depressions (i.e. playing field or park land).

The infiltration basins are modelled by reservoir equipped with pumps stations. The reservoir volume is evaluated multiplying the pervious surface in the basin by the medium pervious depth and taking into account the porosity of the filling materials. The pumps start only if the maximum reservoir capacity is exceeded. The pumped water is sent to the inlet node of the sub-basin and contributes to surface flow.

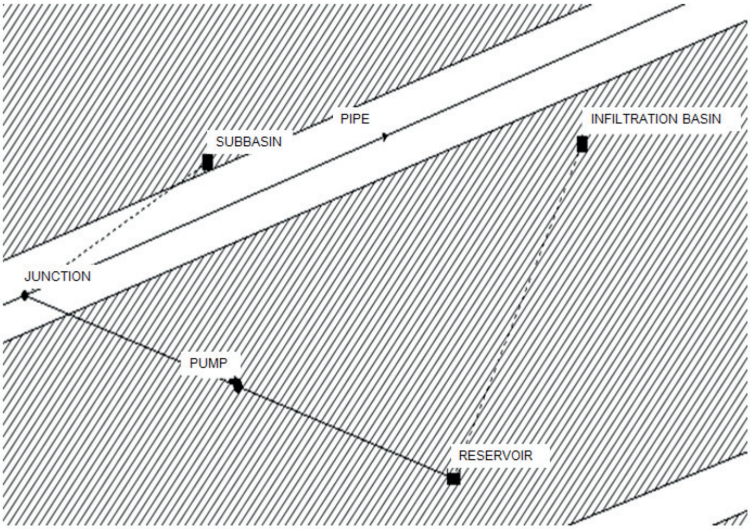

Fig. 3. Details of infiltration basin model -reservoir-pump station (Les détails du modèle de bassin d'infiltration-réservoir-pompe)

Six simulation scenarios are considered: first only one reservoir in the basin, then three reservoirs and finally seven. The last configuration was examined for three different filling capacities.

Figure 4 represents the simulation with seven reservoirs filled to 75% of the capacity compared with the volume obtained without BPM. During the peak there is a lowering of the volume of 45 m^3. Moreover there is small lamination effect.

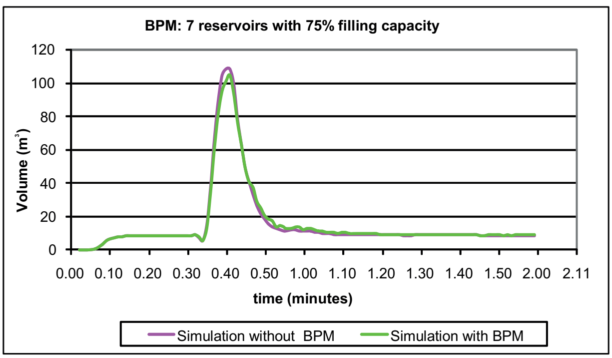

Fig. 4. Comparison of simulations with and without infiltration basins (La comparaison des simulations avec et sans bassins d'infiltration)

2.3 Rainwater tanks

Rainwater tanks are sealed tanks designed to contain rainwater collected from roofs. The main functions of rainwater tanks are:

- Allowing the reuse of collected rainwater as a substitute for mains water supply; and
- Providing some on-site detention, thus reducing peak flows and reducing downstream velocities when designed with additional storage

Rainwater tanks can be either above ground or underground.

Rainwater tanks are modelled as underground reservoir without pump station. Three scenarios are evaluated using different numbers of reservoirs ranging from 1 to 7.

Figure 5 represents the simulation with seven reservoirs compared with the volume obtained without BPM. It is possible to highlight that the volume reduction is of 108 m^3. Moreover there is not lamination effect.

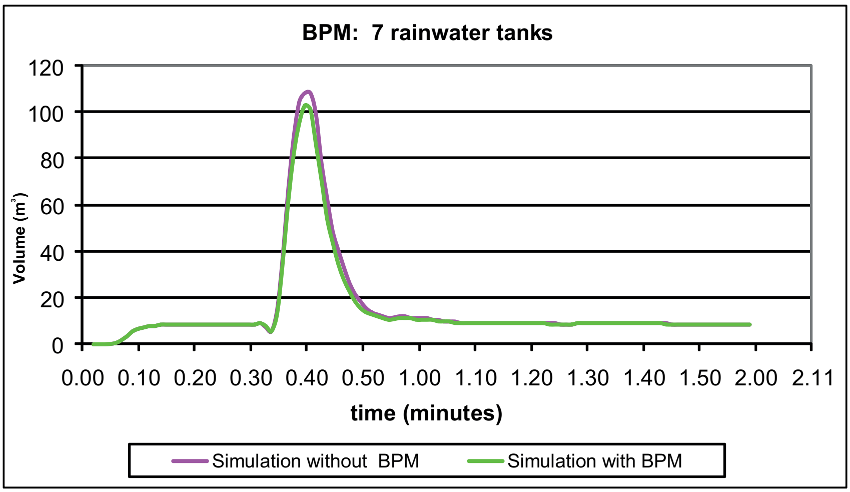

Fig. 5. Comparison of simulations with and without rainwater tanks (La comparaison des simulations avec et sans bassins d'infiltration)

2.4 BPM combined effect

Other two scenarios are simulated for evaluating the combined effect of these two measures. Different reservoir saturation degree are considered ranging from 50% to 75%.

Figure 6 represents the simulation with the combined BPM compared with the volume obtained without BPM. It is possible to highlight that the volume reduction is of 131 m^3. Moreover there is also lamination effect caused by infiltration basins.

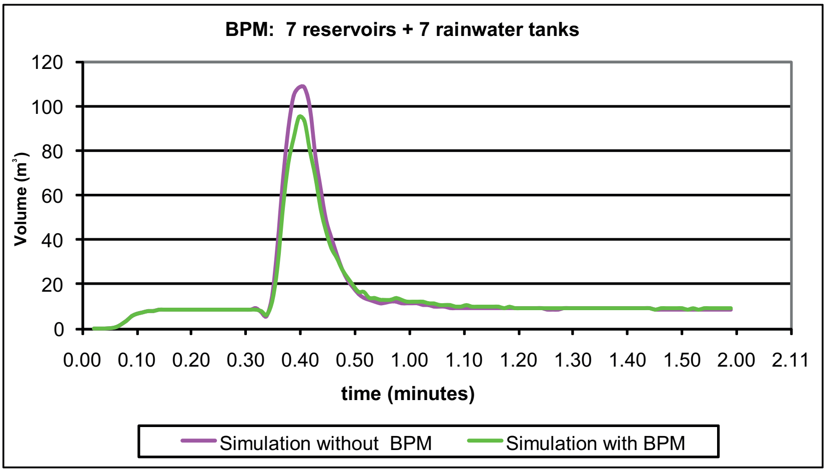

Fig. 6. Comparison of simulations with combined measures ((La comparaison des simulations avec et sans bassins d'infiltration)

3. CONCLUSIONS

In this work an application of BMP is applied to the experimental catchment of Mostacciano in Rome Italy. The examined BMP measures are the infiltration basins and the rainwater tanks.

To perform the analysis the software SWMM 5.0 (Storm Water Management Model) is used. The catchment is divided in 7 subbasins, each characterized by distinct hydraulic, geomorphologic and topographic parameters. Also the BMP measures are represented in the model as subbasins, parameterized in different way depending on their hydraulic behaviour. The model is calibrated by available rainfall and discharge data. Eleven scenarios are built, simulating various soil saturation conditions and percentage of measure application area.

Results are evaluated in terms of flood peak and volume reduction through statistic indexes.

The study highlighted that BMP has reduced the volume and the flood peak. In particular the biggest reductions are obtained when the measures are used at the same time.

REFERENCES

Argue, J.R. 2004. Water Sensitive Urban Design: Basic Procedures for 'Source Control' of Stormwater. Urban Water Resources Centre, University of South Australia.

Coombes, P.J. and G. Kuczera. 2003. Analysis of the performance of rainwater tanks in Australian capital cities. 28th International Hydrology and Water Resources Symposium, Engineers Australia, Wollongong, New South Wales.

Institution of Engineers, Australia. 2001. Australian Rainfall and Runoff – A Guide to Flood Estimation. Revised edn, Pilgram, D.H. (Ed.), Institution of Engineers, Australia, Barton, ACT.

Jonasson, S.A. 1984. Determination of inflitration capacity and hydraulic conductivity. Proceedings of the 3rd International Conference on Urban Storm Drainage, IAWQ/ IAHR, Gothenburg, Sweden.

Rossman, L.A. 2004. Storm water management model, User's manual Version 5.0. Water Supply and Water Resources Division National Risk Management Research Laboratory, Cincinnati.