Assessing the Performance of SuDS in the Mitigation of Urban Flooding: the Industrial Area of Sesto Ulteriano (MI)

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Abstract: Recent development dynamics of urban centres forced administrations to deal more frequently with problems linked to the inability of traditional sewer systems to manage rainwater in a sustainable and effective manner. Currently, several laws require compliance with the quantitative and qualitative stormwater limits to be discharged into watercourses but, in parallel with a "regulatory" approach, integrated strategies are increasingly being developed. A fundamental role is carried out by Sustainable Drainage Systems (SuDS), whose basic principle is the management of rainwater at source through the implementation of prevention, mitigation and treatment strategies. This study, starting from a project proposal made by different Italian firms and funded by PoliS-Lombardia, aims to assess the benefits deriving from the widespread application of SuDS in the Sesto Ulteriano industrial area through a comparison between a scenario that represents the current configuration of the drainage network and an ideal scenario where SuDS are taken into consideration. SWMM5 software was used in order to simulate the behaviour of the drainage network in contexts without and with SuDS after the construction of the synthetic rainfall data sets. Although only event scale simulations have been conducted so far, the encouraging results suggest that these systems can really contribute to mitigating the effects of flooding in urban areas.

Keywords: sustainability; urban floods; green infrastructures

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1. Introduction

The recent development dynamics of urban centers, stimulated by the needs of a population increasingly motivated by economic and social reasons to live in large cities [1,2], have led to a substantial increase in the impermeable surface and a relative alteration of the natural hydrogeological cycle . It was possible to observe, therefore, a visible reduction in the percentage of infiltration, evapotranspiration and groundwater recharge [3].

In particular, in some contexts already characterized by a high degree of vulnerability, such as the Italian territory, this inevitably led to a rapid increase in the hydrogeological risk for the population and the environment [4].

This scenario, therefore, mainly characterized by phenomena such as urban flooding and heat islands, has forced the administrations to more frequently deal with problems linked to the inability of traditional urban drainage systems to efficiently and sustainably dispose of rainwater.

Several laws currently in force require compliance with the quantitative and qualitative limits to stormwater volumes to be discharged into watercourses (Lombardia Regional Low 15 march 2016, n. 4) but, in parallel with a "regulatory" approach, integrated strategies are increasingly being developed. In this kind of strategies, sustainable technologies, able to reduce the flows conveyed in the network and to put into practice policies of redevelopment of the territory, come into play.

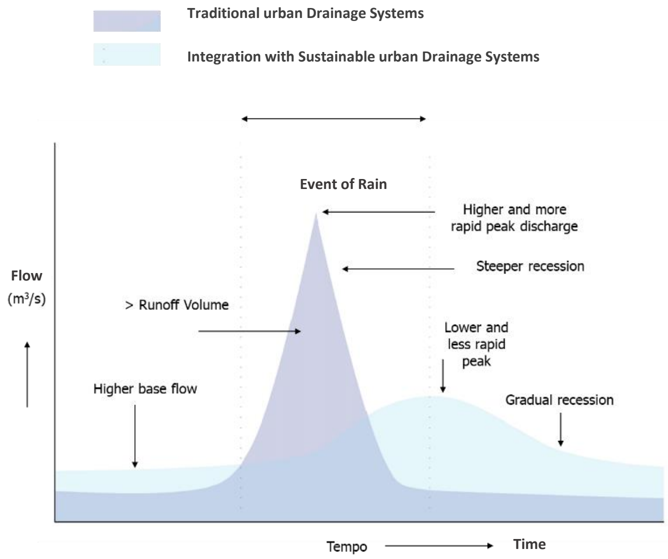

Figure 1. Graphic concept of hydraulic invariance (flow rate limits) and hydrological (flow rate & volume limits).

It is therefore considered essential to change the approach to the urban planning or to modify the already consolidated urban contexts using sustainable drainage technologies able to bring urban systems back to a configuration that is more similar to the one prior to the intensive construction and to the natural pattern. A fundamental role in the implementation of this strategy is carried out by Sustainable Drainage Systems (SuDS), whose basic principle is the management of rainwater at source through the implementation of prevention, mitigation and treatment strategies [5].

This study, therefore, starting from an existing project proposal realized by Studio Majone Ingegneri Associati (Milan), IRIDRA (Florence), Studio Gioia Gibelli (Milan), Studio Idrogeotecnico (Milano) and funded by PoliS-Lombardia (Regional Institute for supporting Lombardia Region policies), aims to evaluate the benefits deriving from the widespread implementation of green infrastructures in the industrial area of Sesto Ulteriano (MI) through a comparison between a scenario that represents the current configuration of the drainage network and an ideal scenario in which different SuDS techniques (rain gardens, ditches and draining stalls, floodable squares, cisterns-planters) have been implemented.

2. Materials and Methods

The in-depth study of the area under analysis (a catchment of about 300 ha in the industrial context of Sesto Ulteriano), the choice and punctual location of sustainable infrastructures in the different homogeneous areas and the construction of a drainage network model able to represent reality using only very few basic simplifying hypotheses, can be certainly considered the real strengths of this work.

In particular, an accurate analysis of study area, included in the municipal territory of San Giuliano Milanese and subdivided for study reasons into 5 different macro-basins, allowed the definition of reference models on the basis of which to articulate diffuse drainage intervention. Specifically, four models have been identified with their respective areas of interest: industrial area model (building, parking areas, squares, flower beds and smaller green areas), road model (roadways, sidewalks, parking lots in line), green areas model and large permeable spaces (parks, uncultivated areas within the urban fabric, green strips belonging to the most important transport infrastructures and permeable or non-permeable areas inside road roundabouts), model of residential areas (buildings). For each of the components, different types of sustainable drainage infrastructures have been identified, designed and placed.

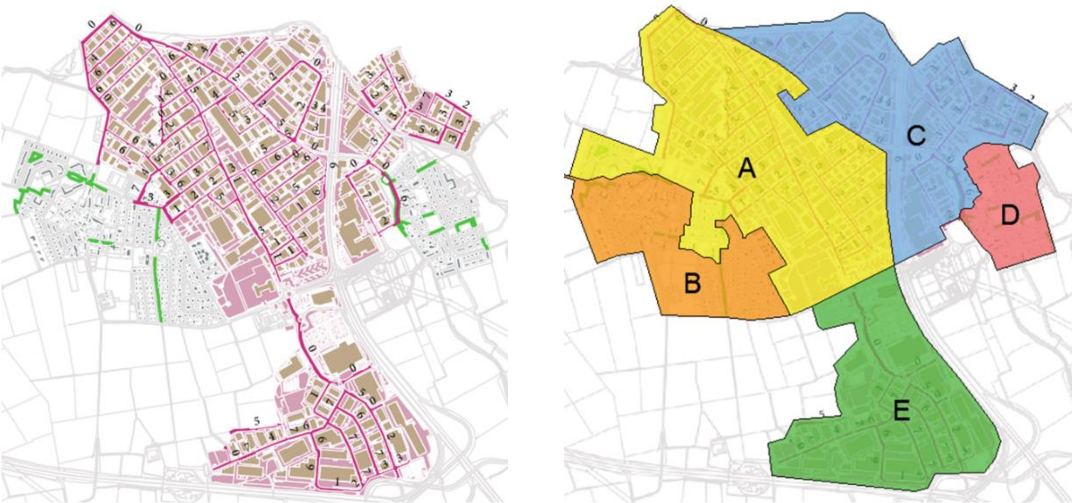

Figure 2. Location of different types of SuDS in the industrial area of Sesto Ulteriano (MI) and subdivision of the study area in 5 macro-basins.

Starting from a modelling scenario of the Sesto Ulteriano drainage network (1148 nodes, 1141 pipelines for a total of 36 km of network), carried out by Studio Majone on the basis of data and information provided by the managing body (CAP Group), steps were taken to implement the different types of SuDS that fell in each sub-basin of the sewer. To this end, therefore, the software SWMM5 of the US Environmental Protection Agency was used.

Comparing the information contained in the Storm Water Management Model 5 file, in particular those regarding the distribution on the territory of the sub-basins of the drainage network and those relating to the spatial distribution of the different types of sustainable technologies available in Quantum GIS, it was possible to derive the areas of each SuDS to be attributed to each sub-basin.

Given the size of the study area, it was necessary to set up a semi-automatic procedure aimed at calculating and assigning parameters and areas where sustainable infrastructures are to be allocated within each sub-basin of the sewage network. Numerous checks were carried out manually by comparing the data available on the QGIS model and that made in SWMM.

3. Results

In particular, it is considered appropriate to present the results relating to the simulation of the effects of two synthetic rain event, one characterized by T = 10 years and the other characterized by T = 5 years, in order to gather some information about the behavior of these technologies in the case of critical events for traditional drainage systems.

Once the interest return periods have been chosen and the intensity-duration-frequency curves (IDF curves) valid for the study area have been identified (data of the Regional Environmental Protection Association of the Lombardy Region were fundamental in this regard), it has been chosen to use a synthetic ietogram of the Chicago type with a duration of 12 hours and peak at 0.3 of duration.

The simulation outputs made it possible to identify, for the two different scenarios, the maximum outflow from each outfalls which, compared with the maximum flow rate allowed for compliance with the invariance principle (for the Lombardia Regional Low 40l/s per hectare of impermeable surface), has allowed to calculate the flow rates to be laminated for each of the outfalls identified (Table 1).

Table 1. Overflow in the different outlet of the catchment.

Area di int	Outfalls	FLOW to be laminated (m^3/s)			
		$T=5_{LID}$	$T=5_{TRAD}$	$T=10_{LID}$	$T=10_{TRAD}$
A	J3	0.76	1.25	1.24	1.29
B	3132	0.64	0.68	0.71	0.72
	3127	1.16	1.48	1.62	1.64
	3275	0.83	0.96	0.98	1.01
C	2862	2.26	2.59	2.74	2.81
	2852	2.52	2.87	3.15	3.23
	J7	2.91	3.05	3.09	3.12
	3155	0.07	0.07	0.07	0.07
	2861	0.54	0.62	0.69	0.69
D	140	1.03	1.32	1.51	1.53
	137	0.91	1.16	1.34	1.35
	127	0.51	0.70	0.79	0.80
	191	0.50	0.64	0.69	0.70
	3150	0.40	0.45	0.48	0.48
	3099	0.50	0.63	0.67	0.67
E	2863	0.00	0.79	0.00	0.85
	3520	3.25	3.66	4.03	4.03

From the graphs shown in Figures 3 (a, b), it is possible to read a visible reduction, following the widespread application of sustainable drainage interventions, of the flow to be laminated (which can also be translated into a substantial reduction in the volumes to be foreseen in the design of first storage tanks).

However, it must be said that these infrastructures are more effective in the case of shorter return periods. A comparison between the simulations carried out with T = 5 and T = 10 years shows, in fact, a reduction in the first case of just over 20% of the flow to be laminated while in the second case of only 7%. It also occurr that some outfalls show a greater reduction than others due to their particular position (purely industrial zone, macro-tanks A, C, E, greater possibility of transforming the impermeable soil with SuDS technologies compared to the residential area).

4. Conclusions

In this study, the assessment of the benefits deriving from the widespread application of SuDS in the industrial area of Sesto Ulteriano has been made. Using EPA SWMM5 software, the behaviour of the drainage network in two different scenarios (with and without SuDS) was simulated in order to understand the differences between the current configuration of the drainage network and an ideal scenario where SuDS have been implemented.

Simulation outputs carried out using synthetic rainfall characterized by retourn period of 5 and 10 year, allowed to identify for the two different scenarios the outflow from each outfall of the network which, compared with the maximum allowed by low (40 l/s per ha of impervious surface), allowed to calculate the flow to be laminated. Results showed about a 20% of reduction for synthetic event with 5-year T and 7% for synthetic event with 10-year T.

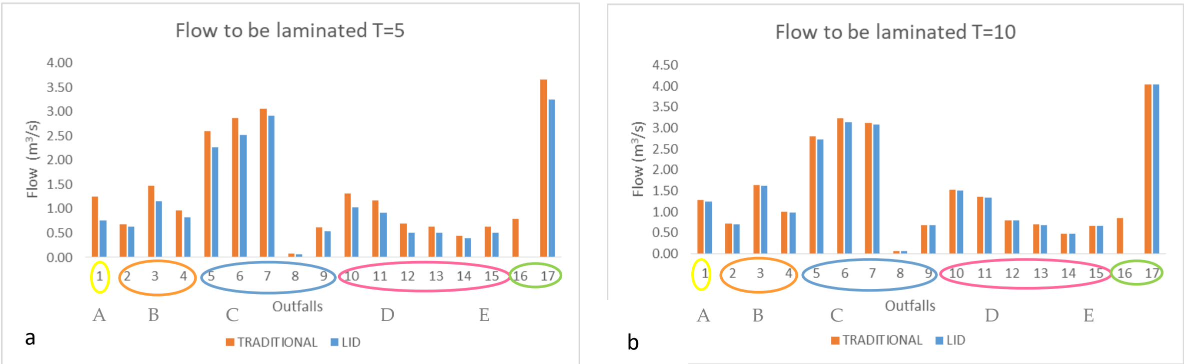

Figure 3. Overflow before and after implementation of SuDS, syntetic event T=5, 10

Surely further simulations are needed in order to study the performance of these technologies under different rain conditions but the results obtained so far surely suggest that SuDS can be considered a valid sustainable solution able to support the traditional drainage systems in the management of stormwater and to provide also other additional benefits in urban centers.

References

1. Galea, S.; Ettman, C. K.; Vlahov, D., *Urban Health*; Oxford University Press: Oxford, United Kingdom, 2019.
2. Tutino, J.; Melosi, W., *New World Cities: Challenges of Urbanization and Globalization in the Americas*; The University of North Carolina Press: Chapel Hill, Carolina del Nord, Stati Uniti, 2019.
3. Masi, F.; Rizzo, A.; Bresciani, R., Sustainable Rainwater Management in the City: Opportunities and Solutions for the Anthropic Environmental Impacts Reduction and Urban Resilience Increase. In *Smart Metropolia*; Obszar Metropolitalny Gdansk-Gdynia-Sopot ul. Dlugi Targ 39/40, 80-830 Gdansk, 2018, 109-119.
4. D'Ambrosio, R.; Sassone, P.; Longobardi, A., Sustainable strategies for flood risk management in urban areas. Enhancing city resilience with SuDS, UPLanD-Journal of Urban Planning, Landscape & Environmental Design (under review).
5. Ballards, B. W.; Wilson, S.; Udale-Clarke, H.; Illman, S.; Scott, T.; Ashley, R.; Kellagher, R., *The SuDS Manual*; CIRIA, London, United Kingdom, 2015.