48. Sustainable Urban Drainage

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Abstract Sustainable Urban Drainage Systems (SUDS) aim the stormwater management by getting the infiltration property of the sealed soils back, as well as its retention capacity and peak flow attenuation. They are essential in urban area over sandy subsoil whose absorption capacity has been voided and need to be regained. It is depicted the situation of coastal residential areas with low slopes and sandy soils, which require pumping to convey the water, and, thus, the energy consumption increases to unsustainable values. Measures favouring infiltration are needed wherever runoff is generated. Catching the stormwater by inlet grates[1] results ineffective because they become obstructed and cause damage to the sewer pipes, thus surface drainage and filtration systems appears as a solution backed by its implementation in countries such as USA, Great Britain and Australia for decades. The participation of stakeholders, manager and citizen, must be considered when implementing this techniques. Cooperation with the stakeholders in the design process is essential to disseminate the knowledge and encourage its acceptance. The ongoing research aims to demonstrate the benefit of efficient and sustainable runoff management as well as the social and economic benefits involved, contextualizing measures in the South of Spain.

Key words Stormwater, Sustainability, Urban drainage, Pollution, SUDS[2]

1 Introduction

The ongoing research focuses on the resolution or mitigation of specific problems of flooding hazard and water pollution in Andalusian urban areas using sustainable techniques and a subsequent comparison with actual techniques. The study goes beyond stating the monetary savings and researches environmental costs including decreased energy consumption (Ramos, Teyssier, Samora, & Schleiss, 2013) and the associated carbon footprint.

[1] Inlet grates: Devices designed to collect excess stormwater from the street, transition the flow into storm drains. Another names: grate inlets, inlet frames grates, drainage grates inlets.

[2] SUDS: Sustainable Urban Drainage Systems.

The unceasing increase of built-up areas and the associated soil sealing has brought about a significant amount of flow on the streets, because rainwater turn into runoff in a percentage by the 100%.

The current system is unable to manage the runoff, by the same time unsustainable economic and environmental costs are generated, not only because the energy consumption but because the pollution involved.

The Spanish Act "*RD 1290/2012 de modificación del Reglamento del Dominio Público Hidráulico* (RD *849/1986)* and the *RD 509/1996* de desarrollo del *RD-Ley 11/1995 de Normas Aplicables al Tratamiento de las Aguas Residuales Urbanas"* reflects the inefficiency of the current system to manage the water, when including in the introduction paragraph that it is impossible to build a sewage system and treatment facilities to deal with all the flood generated in unusual rain events.

Sustainable Urban Drainage Systems (henceforth referred to as SUDS) have been used for decades in countries such as Australia (Wong, 2006), USA (EPA, 2007), Great Britain (Digman et al., 2012; HMSO, 2010), with many others beginning to join the trend.

SUDS, as a prevention tool, are considered since the beginning of the urban planning process through the space reservation to install these techniques. At project level, the generated runoff must be managed, avoiding any discomfort or damage in downstream areas. At rehabilitation level, it is possible to retrofit existing areas (garden, pavement,...) into multifunctional spaces that help with runoff management. SUDS help to minimize detrimental effects in new developments and in consolidated ones.

With a few exceptions, municipal technicians and water utility managers in Spain, and specifically in Andalusia, does not know about SUDS, its efficiency and its implementation and maintenance costs. Contextualized examples are required to its diffusion and acceptation. The present report reflects the condition of the stormwater drainage system in *coastal residential areas at Huelva* (province at the southwest of Andalusia) sometimes non-existent or with a not-working system. This report aims to highlight the need for alternative systems to replace or complement the conventional o current sewerage, increasing the sustainability and efficiency of the system as a whole.

2 Methods

2.1. Method and participation

A key factor is the integration of the different stakeholders taking into account the interested citizens and the water manager opinion.

The participation process can be depicted with a circular figure. Information concerning stakeholders´ pros and contras are obtained when a lap ends, and this could improve a new or second proposal (lap).

Fig. 1 Proposal design and improvement circular process

Contact has been made with the planners and technicians of the City Council - Punta Umbria- and with GIAHSA, the company in charge of the water cycle. The neighbourhood community of *Pinos del Mar* residential area has been also contacted as well as some property owners affected by flooding.

All of them are contributing with information to understand the area, its characteristics and problems. After designing a proposal, their opinions will be added to improve the final design. This process aim a greater involvement and acceptance from the community, and generates a feeling of being part of the idea more than being just the receiver of it.

2.2. Design process

The design of a sustainable urban drainage proposal can be divided in the following tasks:

1. **Environment and runoff**: firstly the analysis of the existing information and making contact with the stakeholders, managers and citizens, to know and characterize the runoff generation.
2. Observed **detrimental effects** and sticking points detection.
3. **Solutions:** conventional (existing or proposed) and proposed solution using SUDS

2.2.1 Environment and runoff

The study focuses on a coastal residential area, *Pinos del Mar*, in Punta Umbría (Huelva), where low-slope and sandy land are occupied by one or two heights buildings. Mainly the local sewerage is a combined system -Combined Sewer Systems (CSS)-, with the usual overflow device - Combined Sewer Overflow (CSO), and with the need of pumping to reach the treatment plant, through all the municipality.

The residential area does not drainage the stormwater and the existing conventional sewerage is generally in poor condition not only because it age but because problems with the pine roots.

Low sloped and sandy lands do not generate a big amount of runoff. No clear river bed can be identified, only some thalwegs[3]. Thus, runoff is mainly generated by the impervious surface of the urban area (roofs, courtyards and streets).

The increasing sealing of the area is similar to another urban area, given that there is no regulation in this regard, nevertheless the residential area still preserve some patios and unpaved streets, with the original sand floor.

Lots are laid out on a grid pattern with asphalt roads in main accesses, with back streets preserving the sand floor, including paved strip for the pedestrian crossing.

The perimeter street drains into the surrounding pine forest, as well as asphalt streets that flow outwards.

[3] Talweg or thalweg is a riverbed outline; a line, as drawn on a map, connecting the lowest points of a valley.

Fig. 2 Back Street at *Pinos del Mar*

Fig. 3 Asphalt road in main accesses at *Pinos del Mar*

Fig. 4 Perimeter street at *Pinos del Mar*

Pinos del Mar borders on a pine forest, property of the city council, excepting the south border that limits with recent urban developments. A project locates a camping in the western border.

The following map (Fig. 5) depicts lowest points (accumulation zones) and the more depressed zones where storm drains -infiltration SUDS- can be settled in.

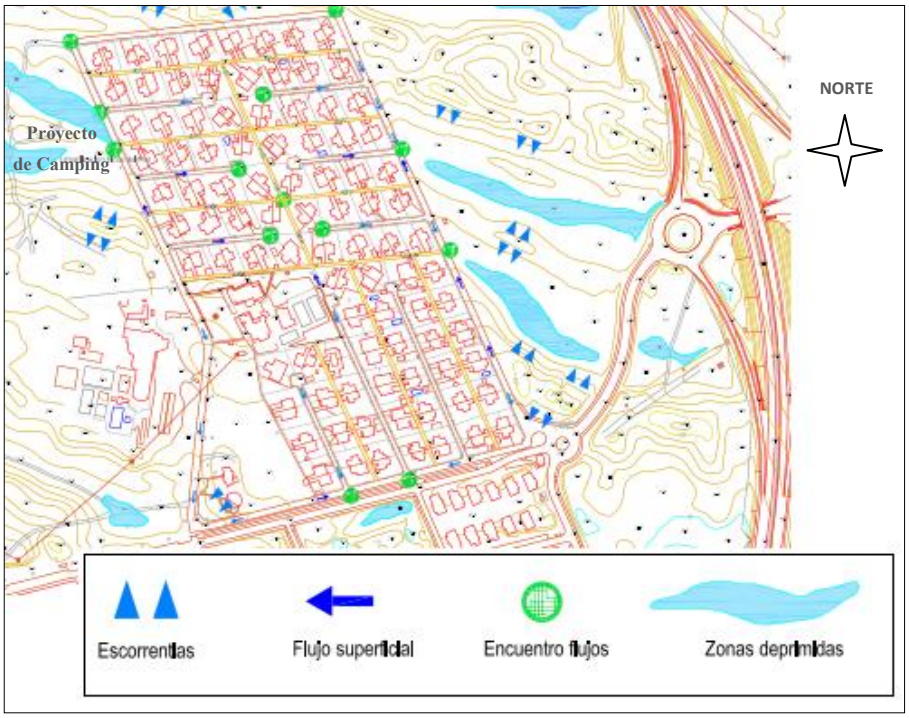

Fig. 5 Surface flow direction in *Pinos del Mar*

2.2.2 Detrimental effects

In regard with the flood there are some detrimental effects and sticking points in some rain events, which are aggravated by the sewerage condition, in *Pinos del Mar*. The damage occurs at cul-de-sac streets that drains inwards and at inner points in sand streets due to a lack of outward slope (green circles are *'water accumulation*' depicted in map figure 5).

Thus, the residential area has the twofold task of addressing stormwater drainage management and water accumulation in some interior points.

2.2.3 Solutions

CONVENTIONAL SOLUTION

There is a project for the conventional management of the stormwater in *Pinos del Mar*, in other words, for catching the water by inlet grates and conveying it to

storm tanks. When managing the water in the tanks and treating the pollution swept along, pumping will be required as well as associated energy consumption (carbon footprint).

Concerning the performance, the conventional sewerage has been analyzed in a nearby urbanization in order to establish a comparison with the alternative solution or SUDS. It is called *La Canaleta*, with similar characteristics, flat and sandy, with a unitary sewerage that includes some separate pipes for stormwater. *Detected system malfunctions and risks* are set out below.

Drainage malfunction

Even though the stormwater drainages appears to be solved at *La Canaleta* by the current conventional system, however, it is far from being solved at all.

After the visual examination of the area and as depicted in Figure 6, it remains a matter of doubt whether the drainage system is working or not.

Fig. 6 Inlet grates *at La Canaleta*

Inlet grates, blocked up or just sealed, does not catch water at all. Moreover, the pipes could be partially blocked up too by material swept through the grates before they got completely disabled.

The sewerage, with some dilapidated parts, also receives in some sections the runoff from the inlet grates that gains access to the pipeline. Therefore, installing inlet grates in sandy areas, that catch water and sweep along sand and pollution, does not seem to be the effective solution.

The increasing soil sealing

To this sewerage ineffectiveness situation must be added the growing soil sealing. At *La Canaleta* where once there were streets of sand now there are asphalt streets. This traffic enabling supposes a disabling for the management of rainwater. The sealing of the sand soils closes *the great natural drain* that is the original soil.

Fig. 7 Sand street with pedestrian strip and asphalt street at *La Canaleta*

Likewise, property remodelling often eliminates the sand surface and replace it with pavement, with the consequent increase of runoff.

Fig. 8 Pedestrian paths, sand, and court imperviousness at *La Canaleta*

Lack of information. The unknown sewerage

The author's experience highlights the relatively widespread absence of knowledge of the existing buried pipeline. Sometimes, because there are not a map depicting it and others because reality differs from the mapping information. In addition, technicians have pointed out the usual illegal connections to the sewerage. Thus, the buried pipeline can be illegally connected, without control by the authorities about where sewage could be being drained.

ALTERNATIVE SOLUTION: SUDS

The SUDS solution not only manages runoff but also incorporates measures to avoid its generation which is a big difference from conventional drainage.

Thus, it is required to put a curb on two inertias, that one concerning the soil sealing at yards and streets, and other one concerning the conventional stormwater management using only the underground pipelines. It is required to highlight the need for changes in the stormwater management.

1st SUDS measure ⇨ **Dissemination and knowledge of SUDS. Stakeholders integration.** Meetings between technicians, governors and water managers and

the citizens involved are needed to transfer SUDS knowledge. This will bring together latent environmental sensitivities, and convince others one when showing analyzed and tested solutions.

2nd SUDS measure ⇨ **Sand streets conservation. Put a curb on property imperviousness.** Drainage solution in this kind of low slope areas can be defined as *the recovery of the large natural inlet or drain that are the sandy subsoil*. In *Pinos del Mar* rather than recovery is "maintenance" of the current situation, putting a curb on the surface imperviousness.

3rd SUDS measure ⇨ **Existing runoff management** by surface drainage, pollutants filtering and infiltration into the subsoil.

Here, it is fundamental to underscore that stormwater are excluded in current legislation from being considered as a discharge and, therefore, from the need for treatment. In Andalusia, discharges to the Public Hydraulic Domain and Coastal Waters are regulated by *Decreto 109/2015* which also develops the Law *3/2015 GICA*. For the purposes of this Law **it will not be considered discharge:**

> (A) Drainage of waters which are not polluted or which have not come into contact with polluting substances, such as **clean stormwater** and water from extensive or traditional aquaculture.
> B) Outfall to areas not included in the Public Domain Hydraulic and Coastal Water and **that do not affect them**.[4]

Even though, SUDS includes a primary treatment of stormwater through filtration devices.

In the coastal plain, given the low slope and height above sea level, the drainage towards the coastal water will not work, but rather towards the area of pine forests with space for small areas of retention and infiltration.

Thus, in the perimeter road **bioswales** will be proposed that filter, infiltrate and convey excess flow to the **retention and infiltration areas in the pine forests.**

Infiltration trenches or wells will be proposed in asphalt streets draining inland, designed to retain the flow that causes affection. Grid polypropylene boxes[5] designed for traffic loads are recommended when designing this kind of SUDS.

[4] Translated by the author from the original text.

[5] Modular, three-dimensional, hollow, vertically and horizontally perforated, boxes made of polypropylene designed to store water underground designed to store (and/or infiltrate) water underground

Fig. 9 SUDS designing plan in *Pinos del Mar*

In the present case, there is no a planned connection between SUDS and the buried pipeline, since there is space to retain and infiltrate the excess flow. Otherwise, in consolidated areas, with no space for installing SUDS to retain or attenuate peak flow, the spillway or drain is connected to the conventional sewerage.

2.3. Comparison and appraisal

Comparison between conventional (buried pipelines and pumping) and sustainable (SUDS) alternatives has not been established, as this is an ongoing investigation, as well as the subsequent appraisal or review from neighbours and managers.

Added benefits will be considered when comparing, such as the improvement in local job opportunities as it is required a increase in green areas maintenance. It has been shown in other countries experiences (Escuder-Bueno et al., 2012; Oke & Maxwell, 1975) that the cost reduction in consumption of energy and other resources to manage the urban water can be invested in community employment, e.g. strengthening maintenance work crew.

3 Predictable results

The main conclusions of the work will be to demonstrate that the choice of sustainable technique is the right decision for mitigation of conflicts associated with floods and water pollution in urban areas.

Table 1 Predictable results between conventional and sustainable solutions

SOLUTION	CONVENTIONAL	ALTERNATIVE -SUDS-
Knowledge	↑ YES (1)	↓ NO
Increase run-off	↑ YES (2)	↓ NO
Energy consumption	↓ High	↑ Low
Costs	↑ Greater knowledge costs	↓ Maintenance costs uncertainty (3)
Environment improvement	↓ Low	↑ High: landscape quality, air,...
Heat island effect	↓ No affection	↑ Urban temperature improvement
Climate change	↓ Not adapted	↑ Adapted
Pollution	↓ Diffuse and poorly controlled	↑ Source control
Social integration	↓ None	↑ Local job increasing
Liability sharing	↓ None (4)	↑ With citizens (5)

(1) Its design is known, also its malfunction when managing stormwater

(2) Soil sealing inertia and conventional stormwate. r management (pipelines, storm tanks) may not only aggravate the situation but increase the costs.

(3) Many of the costs and benefits considered are quite accurate for the usual conditions, even though, UK experience is limited in the maintenance and operation of the SUDS and therefore the costs are uncertain (Digman et al., 2012).

(4) Stormwater drainage is a municipal liability

(5) Citizen integration in the process of design provides information about run-off generation. Individual liability is glimpsed.

It is expected that the results will not only demonstrate the environmental benefits of sustainable measures, but will also highlight social advantages, through specific research located in Southern Spain urban area.

4 Citation and References

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