Rain gardens: green infrastructure typology for the Santos, SP

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Abstract

Currently, the development of big cities has been characterized by a great number of constructions, the total paving of streets and beyond the priority given to the automobile as opposed to the human being. Those factors contribute to the impermeability of the soil, thus influencing directly on the water route. As a mitigating measure, there is a possibility to insert elements which may help pluvial drainage, besides enhancing the beauty of the urban landscape. Those elements are known as typologies of spaces which are treated landscape projects and are applied as part of a green infrastructure network. Facing the need to present new proposals which provide greater support to sustainability, this paper aims to evaluate the typology of *Rain Garden*, which contribute to the removal pollutants, with the infiltration and retention of water volumes precipitated in the city of Santos. That city was chosen because for the past few years it has been affected by the construction of a large number of buildings, as well as permeable areas. As the region usually has a considerable pluviometric index, flooding is likely to occur in certain spots. For this study we have performed an experiment simulation, using a plastic box with a perforated base, with an area of 0,104 m², containing the background a *geotextile* blanket and substrates of sand and organic soil. The results showed that in the worst storm conditions (150 L/m²/h); it is possible to obtain system water retention of about 20%. These numbers allow the indication of planting 10 native plant species compatible with requirements.

Keywords: green infrastructure. rain garden. native species. urban ecology. sustainable garden;

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Jardins de chuva: tipologia de infraestrutura verde para Santos, SP

Resumo

Atualmente, o desenvolvimento das grandes cidades tem se caracterizado pela grande quantidade de novas construções, com pavimentação total das vias e também da prioridade do automóvel em detrimento do ser humano. Estes fatores contribuem para a impermeabilidade do solo, influenciando diretamente no curso das águas. Como medida atenuante, existe a possibilidade de inserir elementos que possam ajudar na drenagem pluvial além de atuar no embelezamento da paisagem urbana. Estes elementos são conhecidos como tipologias de espaços tratados paisagisticamente, e são aplicados como parte de uma rede de infraestrutura verde. Diante de tal possibilidade, este artigo propõe avaliar a adequação da tipologia *Jardim de Chuva*, que contribui para a remoção de poluentes, infiltração e retenção dos volumes de água precipitados nos espaços públicos e vias urbanas, na cidade de Santos. A cidade em questão foi escolhida porque nos últimos anos vem sofrendo com o grande número de novas edificações e áreas impermeabilizadas. Como a região costuma ter um índice pluviométrico anual considerável, acaba formando pontos suscetíveis a alagamentos. Neste estudo foi efetuado um experimento de simulação para encontrar o melhor dimensionamento do jardim, com uso de uma caixa plástica de fundo perfurado, com área de 0,104 m^2, contendo manta geotêxtil ao fundo e substratos de areia e solo orgânico. Os resultados mostraram que nas piores condições de chuva (150 $L/m^2/h$), é possível se obter uma retenção de água no sistema de cerca de 20%. Estes números permitiram a indicação de dez plantas nativas da mata atlântica compatíveis com o experimento.

Palavras-chave: infraestrutura verde. jardim de chuva. espécies nativas. ecologia urbana. jardim sustentável.

Introduction

The green infrastructure is a concept that has evolved for the past few years and has reached a high degree. It has fundaments of urban ecology and views the city in an integrated way.

According to Herzog (2013), green infrastructure is an urban ecological network which restructures the landscape and mimics the natural processes in order to maintain or restore the urban ecosystem function.

Therefore, it helps to prevent floods, moderate heat islands, balance biodiversity, reduce greenhouse gas emissions and improve people's life quality by making the city a healthier place.

As clearly described by Cormier & Pellegrino, currently a movement has been acknowledged in American and Canadian cities and it is creating urban landscapes which,

> Are part of a strategy to implant urban open spaces, which are treated as landscape projects, aiming much more than being mere city embellishment, but also to perform infrastructure functions related to the management of urban water, environmental comfort, biodiversity, mobility alternatives, accessibility and local image.
> (CORMIER & PELLEGRINO, 2008, p.127).

In Europe, several countries also use green infrastructure as an integrated part of urban landscape, inserting diverse typologies in public spaces such as rain gardens, biogutters, rain lagoons, green roofs, cisterns, to mention a few. Those typologies work in an integrated way, thus creating a green interconnection which meets the ecological criterion of sustainable urban spaces, widely and efficiently.

In Brazil, some attempts to implant green areas in the typologies mentioned above are being made most of which modestly and without an interconnection. That creates fragmentary, inefficient public spaces, in an ecological point of view.

Therefore, it is necessary to conceive new strategies in which urban space is thought of as an urban ecosystem, connected to the natural ecosystem, which allows for biodiversity balance through the integration of green areas, resulting in more ecological and sustainable cities.

According to (HERZOG & ROSA, 2007) if green infrastructure is well planned and managed, it may give a support to city resilience by adapting and regenerating urban tissue, which be comes more resilient to the impact caused by climatic changes.

From those concepts, one of the models chosen for this study is the *Rain Garden*, also known as Bioretention System. Those gardens use plants and micro-organism biological activities to remove pollutants from pluvial water and contributes to the infiltration and retention of rainfall volumes, thus decreasing the surface runoff.

In addition, it helps the maintenance of biodiversity, moderating heat islands, evapotranspiration and carbon capture among others (HERZOG, 2013).

The city chosen to be the study area was Santos, SP. It is a port city with 420.000 inhabitants and currently, the tenth biggest city in the state, with great importance in the economic, social and environmental scenarios. Well known for having the longest beach garden in the world, Santos still lacks more green areas in some neighborhoods, in order to provide the city with a bigger environmental balance.

This paper aims to present a technique which will develop the *Rain Gardens* in squares and streets in Santos, using laboratory experiments.

Materials and Methods

In order to mimic the effect of the rainwater in a city, with later capture before getting into the conventional drainage system, an experiment was made (Figure 1) at the Mechanics of Soils Lab at the " Universidade Santa Cecília". In a 0,104 m², plastic box with a perforated bottom, a system as follows was set up: a geotextile blanket (Bidim) was placed at the bottom in order to avoid the migration of the second layer (sand); this was covered with sand (1/3 of the height of the box); the remaining space was filled with organic soil. An aluminum tray, with a set of PET (Polyethylene Terephthalate) bottles positioned vertically to retain part of the waste water after the watering of the system, making the reutilization of the retained liquid possible, was placed under the plastic box. This was done to evaluate its water-retaining potential and its performance on the constant humidification of the vegetation so as to diminish the frequency of irrigation. The remaining space between and around the bottles was filled with grit to hold them. Considering the value of the annual period of rain recurrence in Santos, which is 150 L/m²/h, the model was submitted to controlled irrigation, mimicking the real indexes. The criteria for the vegetation choice to be used were the origin of the plant (native) and its edaphic demands (LORENZI & SOUZA, 2001).

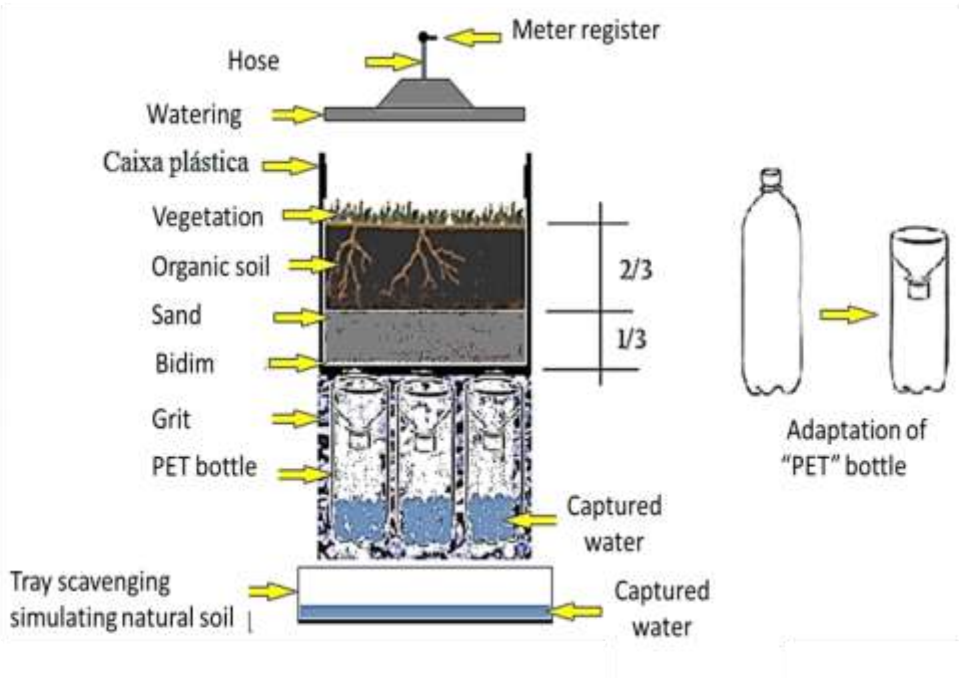

Figure 1: Schematic of the model developed in the laboratory.

Results and Discussion

The calculations of the volumetry corresponding to the maximum amount of rain in Santos for a period of one hour (150 L/m²/h) resulted in 16 L/water/h. After irrigating the system for an hour at 4,44 mL/s, the water penetrated the organic soil and saturation occured after 24 minutes and 50 seconds; from that time on the water went through the following layers and drained off to the lower part of the system, where a tray with PET bottles had been placed. When the dripping was totally over, which occurred seven minutes after the drain-off started, the experiment came to an end.

The volume of the water retained in the bottles, as well as that in the tray, was measured. There were 3,14 liters of water in the bottles (almost 20% of the spillover volume in the system); a total of 4,96 liters (31% of the spillover volume) remained in the tray. The remainder of the water (49%) remained in the system and was to be gradually released either through evaporation or root absorption, after the insertion of plants.

In a conventional rain garden like the one the one presented in Yazaki's paper (YAZALI, 2013), after a rainy period, the water was drained and the Garden depends on care to keep its ideal living conditions. This experiment showed that, through the use of PET bottles, it is possible to retain the largest amount of water in the system, and thus, prevent flooding, which quite common after high pluviometric levels in the surrounding areas where the rain garden was implanted. Besides, the system can work as an irrigator, in capillary movement, through permeable material, and thus decreasing the need for constant maintenance.

The figures obtained for liquid retention allowed for the indication of ten species of plants to be used in the Garden. (Table 1).

Final Considerations

Many cities are seeking new ways of bringing better quality of life to their populations, with a wider, more holistic approach, integrating the existing natural areas to the dense urban context.

Seen here as the green areas in the city, the urban public space manages to reposition itself through green infrastructure and makes ecological revitalization possible, changing the urban landscape and mitigating the harmful effects of disorderly growth.

However, this positive result will only be possible if there is interdisciplinary work in the several areas linked to urban planning, landscaping, ecology, sustainability, botanic, engineering, architecture and many others that may be relevant.

The main goal of this study is to make it possible to implant the *Rain Garden* typology on side walk streets and squares in Santos and therefore, provide the city with a new green area system through which the use of biological activity of selected plants (Table 1) will contribute to the infiltration and retention of rainfall.

The data in this study should contribute to next phase of the research, which will consist of implanting a rain garden pilot project into the Universidade Santa Cecília campus. The opportunity to test it in a place with real climatic conditions will bring better foundation for future results, besides making way for its implantation in public spaces in the city.

Table 1. Recommended species for planting on side walks in Santos (SP). TV = trivial name; TES = total exposure to the sun; PH = preference for humidity; PS = partial shade; IF = irrigation frequency; PS = planting sites; BS= blooming season; AF= attractive features.

Espécie	TV	TES	PH	PS	IF	PS	BS	AF
Justicia scheidweileri V.A.W.Graham	"camarão-rosa"			x	frequent	flowerbeds	spring, summer	dark green leaves with whitish lines on the ribs; showy red bracts, purplish tubular flowers
Arachis repens (Handro)	"grama-amendoim"	x			periodic	flowerbeds	spring, summer	dark green leaves; yellow flowers
Ruellia puri Mart.ex Nees	"ruélia-azu"l	x	x	x	frequent	flowerbeds	fall, winter	showy bluish flowers bell-shaped
Alternanthera brasiliana (L.) Kuntze	"periquito-gigante"	x	x		periodic	flowerbeds	all	purplish or reddish-purple leaves
Chamaecostus cuspidatus (Nees & Mart.) C.Specht & D.W.Stev.	"cóstus-de-fogo"		x	x	frequent	edge, flowerbeds	all	bright green leaves, fleshy, yellow-orange flowers
Begonia reniformis Hook.	"begônia-folha-de-videira"		x	x	frequent	maciff, flowerbeds	all	large leaves, variables, hairy
Centratherum punctatum Cass.	"perpétua-roxa"	x	x		frequent	maciff, flowerbeds	all	velvety-pubescent leaves, serrated margins
Sphagneticola trilobata (L.) Pruski	"mal-me-quer"	x	x	x	periodic	edge, flowerbeds	all	showy yellow chapters
Unxia suffruticosa (Baker) Stuessy	"botão- de-ouro"	x	x		frequent	edge, flowerbeds	summer	chapters flashy yellow-gold
Gloxinia sylvatica (Kunth) Wiehler	"semânia"		x	x	frequent	edge, flowerbeds	all	elongated leaves, red flowers yellow throat

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