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Opportunities and challenges in the use of Nature-based Solutions as complementary measures to the "Novo Rio Pinheiros Program" in São Paulo city

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Highlights:

- The Novo Rio Pinheiros Program aimed to improve the environmental recovery of the Pinheiros River and benefit the population.
- The potential use of Nature-Based Solutions (NBS) was analyzed, contributing to the achievement of the goals of the Novo Rio Pinheiros Program.
- The systematic review of the literature addressed case studies with NBS to mitigate urban flooding and water pollution.
- NBS performs rainwater management at the source, such as retention, filtration, infiltration, absorption, evaporation, treatment, storage and reuse.

Keywords: Nature-Based Solutions; Novo Rio Pinheiros Program; Recovery of watersheds.

INTRODUCTION

The accelerated growth of the city of São Paulo has imposed complex challenges on conventional drainage systems, with an increase in the frequency of floods of small and large magnitudes, bringing relevant losses to the city and its citizens (PMSP, 2022). This process is aggravated by urban occupation in floodplains and valley bottoms (PEIXOTO, 2017). Other effects are the impacts on water quality in urban streams and rivers, which deteriorate due to pollutants transported in rainwater networks, coming from diffuse and point sources of pollution (RIGHETTO et al., 2017). With the worsening of climate change, water and sanitation are emergency issues to be faced in search of a better quality of life and well-being (HERZOG, 2020; DHARMARATHNE et al., 2024; SU et al., 2024), becoming the main contemporary challenges faced by the urban population.

The Novo Rio Pinheiros Program of the Government of the State of São Paulo implemented joint actions of public agencies, private partnerships and society. The Program's environmental depollution goal aimed to collect the sewage discharged into its tributaries, remove waste and sediments from the riverbed, rebuild the riverbanks, recover aquatic life and enable the return of the population to its banks, also through the environmental and landscape recovery of its surroundings (SEMIL, 2024). The objective of this study is to analyze the potential use of Nature-Based Solutions (NBS) in the mitigation of stream pollution and urban flooding. And, finally, to contribute to the identification of opportunities and challenges for the implementation of NBS in the Pinheiros River basin, in São Paulo.

METHODOLOGY

This study is divided into three distinct parts directed towards specific objectives. Thus, the first study aimed at a systematic review of the literature with case studies adopting NBS as sustainable measures in urban water bodies to improve water quality and for flood control. The second study aimed to analyze the sub-basins of the main tributaries of the Pinheiros River with the most critical pollution conditions. And the third study aimed to analyze the most critical areas of urban flooding in the Pinheiros watershed.

The systematic review of the literature investigated publications with NbS for case studies, obtaining results in the recovery of water quality and the reduction of urban flooding. The analysis of the tributary streams of the Pinheiros River under more critical pollution conditions was associated with the Water Quality Index (WQI) monitored by the Environmental Agency of the State of São Paulo (CETESB). The urban flooded areas were obtained by the hydrological risk mapping of the City of São Paulo available in the Geosampa System.

RESULTS AND CONCLUSIONS

The most recent data published in the Inland Water Quality Report (CETESB, 2022) show that the WQI in the Pinheiros River exceeded the historical average of the last 5 years. The data reveal the WQI category in good quality in the upstream stretch of the river, but with a bad result in the middle stretches and very poor in the downstream stretch at the mouth of the Pinheiros River. Regarding the WQI of the tributary streams, it is worth highlighting the requalification of the Poli and Águas Espraiadas streams, indicating a trend of improvement compared to the historical average. The Dom Bosco and Corujas streams remained in the Regular category of the IQA. As for the streams that declined the WQI results, the Judas stream went from the Good to the Regular category; the Jaime Oliveira stream went from the Regular to Poor category; and the Cordeiro and Alexandre Mackenzie streams from the Bad to Very Bad category. The other tributaries of the Pinheiros River maintained the classifications in the Poor and Very Bad categories, in the same historical average.

The analysis of areas at risk of urban flooding was done with geographic information system (GIS) software using shapefile data obtained from GEOSAMPA (PMSP, 2024) and identified an area of 19.26 square kilometers (Km2), corresponding to 7.08% of the total area of the Pinheiros River basin. Most of this flood area represents the floodplain area of the Pinheiros River from the middle stretch of the river to the mouth, in the flow with the Tietê River. The largest areas subject to flooding risks located on the left bank in the downstream stretch are in the Pirajuçara stream with almost 4 km2 of area at risk of flooding, followed by the Jaguaré stream with just over 1.5 km^2. And in the upstream section, the Morro do S stream, with almost 1 km2 of area subject to flooding. On the right bank, in the downstream section, the largest area subject to flooding is the Ceagesp contribution area, with just over 3.1 km2. In the middle stretch, the Uberaba stream, followed by the diffuse contribution area of the Brooklin drain and the Águas Espraiadas stream, add up to almost 2 km2 of area subject to flooding. Through cartographic images in the ArcGIS software, urban spaces with the existence of vegetated areas were studied, for example, stream banks, squares, avenues and streets, and alternatives were designed for the implementation of NBS throughout the Pinheiros River basin. Figure 1 identifies the typologies with NBS georeferenced on the map of the Pinheiros River basin.

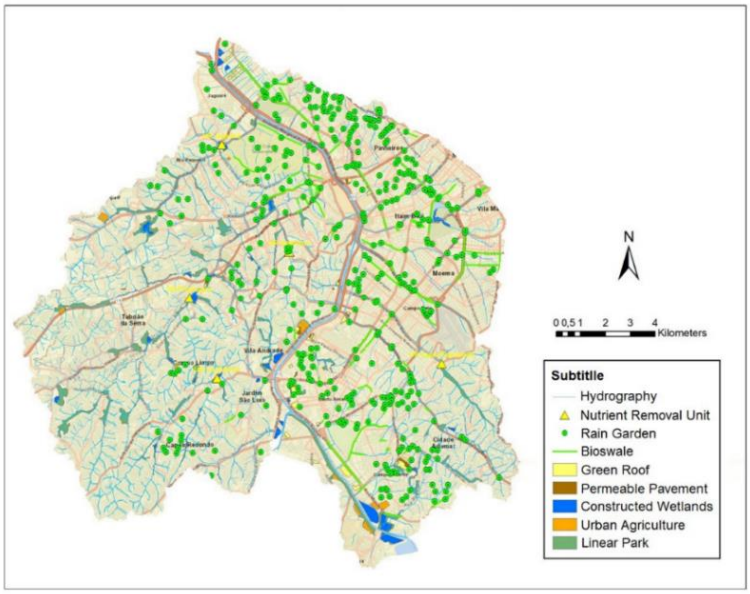

Figure 1 – Map of NBS alternative in the Pinheiros River basin

The main NbS findings obtained in the systematic literature review support the potential use of alternatives such as constructed wetlands, linear parks around streams, areas with urban agriculture, rain gardens, bioswales, parking lots with permeable pavements and green roofs. Based on the types of NBS analysed, the opportunities and challenges encountered are:

Opportunities: 1) Contribute to a decentralized and low-cost solution to contain point and diffuse pollution near the generating sources; 2) Are efficient in removing phosphorus, nitrogen, organic compounds and sediments; 3) Provide alternatives for the treatment of domestic sewage in informal areas without public sewage services; 4) They represent multifunctional solutions that add ecosystem services in the city; 5) Provide landscape resources.

Challenges: 1) Require available and appropriate urban spaces in densely occupied places; 2) Need, under specific conditions, to expropriate land and buildings for the construction of linear parks or green corridors; 3) They require several adaptations in the streets and avenues for the implementation of natural infrastructures; 4) Innovation and experimentation of decentralized systems practices for sewage treatment with vertical and horizontal wetlands in slum areas, valley bottoms, slopes and stream banks.

This scientific work concluded that NBS promote sustainability in urban watersheds by retention, filtration, infiltration, absorption, evaporation, treatment, storage or reuse of rainwater. In addition, they provide multiple benefits to the landscape and the ecosystem. NBS projects must take advantage of unbuilt free spaces in public places, such as squares, parks, streets, avenues and stream banks. In the more urbanized regions of São Paulo with more green areas available, such as squares and parks, NbS typologies such as bioswales and rain gardens are more favorable, and in the peripheral regions of the city, with a predominance of narrow streets and the absence of public green areas, linear parks are more favorable for improving the environmental quality of streams and expanding leisure spaces for the urban population.

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