Wastewater treatment solutions for irregular settlements

Gerke, M.L.R.*, Hoepers, T. R.*, Monteiro, M. M.*, Fabiani, A.L.T.*, and Santos, D. C.*

*Universidade Federal do Paraná, Programa de Pós-Graduação em Engenharia de Recursos Hídricos e Ambiental (PPGERHA), Avenida Coronel Francisco Heráclito dos Santos, 100, Jardim das Américas, Caixa Postal 19011, CEP 81531-980, Curitiba, Paraná, Brazil.

Highlights:

- Community-driven sanitation solutions must align with local cultural, technical, and environmental conditions for effective implementation in irregular settlements.
- Strategic placement of decentralized sanitation systems is crucial in informal urban settlements.
- Decentralized systems are vital for improving sanitation in communities without public sewage infrastructure.

Keywords: decentralized systems; irregular settlements; wastewater treatment.

INTRODUCTION

Disorderly urbanization, income inequality, and real estate speculation have led to the illegal occupation of environmentally restricted urban areas with inadequate sanitary infrastructure (Gomes, 2009). These irregular settlements have distinct characteristics that require context-specific sanitation technologies, considering social, technical, and environmental factors (Gomes, 2009; Souza, 2019). In such contexts, decentralized systems offer a viable solution, as they are simpler and cheaper to install than centralized systems (Tonetti et al., 2018).

Considering the prevalence of irregular settlements in municipalities surrounding major Brazilian cities (Souza & Samora, 2022), this research focuses on the Favorita community in the Metropolitan Region of Curitiba, Paraná. Favorita is an irregular settlement facing critical challenges, including inadequate wastewater management and limited access to basic sanitation services, rendering it an ideal case study for assessing the viability of decentralized sanitation solutions.

The objective of this study is to assess decentralized sanitation technologies that are technically feasible, socially acceptable, and environmentally beneficial for implementation in irregular settlements.

METHODOLOGY

The methodology developed in this research offers a framework for selecting the most suitable sanitation solutions for irregular settlements facing socio-environmental challenges, particularly in urban areas with environmental fragilities and space constraints. This framework consists of four steps:

(A) socio-environmental diagnostics, (B) technical screening of technologies, (C) community-based evaluation, and (D) grouping feasible solutions for decentralized wastewater systems and selecting the most appropriate system.

In the initial phase of the research, the Favorita community was comprehensively examined in terms of its physical, biological, socioeconomic, and sanitary aspects. Field visits were conducted with the assistance of a local leader, and data were gathered from various sources, including books, prior studies, documents, and platforms such as the National Spatial Data Infrastructure (INDE).

Subsequently, the technical feasibility of several technologies was evaluated. Factors such as water table depth, soil type, road infrastructure, and available space were considered during this screening process. Technologies that proved feasible were further assessed for their cultural compatibility and ability to address the community's specific needs, particularly concerning odor management and maintenance. These technologies were categorized into sewage treatment systems, to calculate the necessary installation areas and determine their optimal placement within the community. Based on these evaluations, the most suitable group of sanitation technologies was recommended.

RESULTS AND CONCLUSIONS

The Favorita community covers approximately 138,000 square meters (Ribeiro et al., 2018) and includes 763 lots (Humanize Land Regularization and Social Urbanization, 2022). Research by the non-governmental organization TETO (Ribeiro et al., 2018) highlights the community's expressed need for improved sanitation solutions.

Sewage is primarily discharged directly into the stream bordering the community (Ribeiro et al., 2018). The main method of sewage conveyance is through resident-constructed networks, which are poorly maintained and exposed in several areas. In the absence of a public sewage network, utilizing these existing structures to direct sewage to a decentralized treatment system is crucial. Therefore, the proposed solution relies on these networks.

The community's needs and the site's characteristics that most limit technology selection include the shallow depth of the water table, lack of space, community sensitivity to odors, inadequate road infrastructure, and system costs. Given these constraints, the initial assessment identified a singular option for primary treatment and three alternatives for secondary treatment, leading to three potential system configurations.

The chosen primary treatment for all three configurations was the septic tank. For secondary treatment, infiltration trenches, anaerobic filters and vertical subsurface flow wetlands were considered. However, upon calculating the spatial requirements, only the anaerobic filter was found to be compatible with the available community space.

Considering the topographic features and layout of the settlement, six wastewater treatment plants were proposed to service the 763 lots in the area, as illustrated in Figure 1. Due to the limited space elsewhere, five of these treatment plants were located within the Permanent Preservation Area of the Favorita

stream, as defined by the Brazilian Forest Code (Law No. 12.651/12). Despite environmental concerns, placing the treatment plants in this Area has a lower impact compared to leaving the community without adequate sewage treatment.

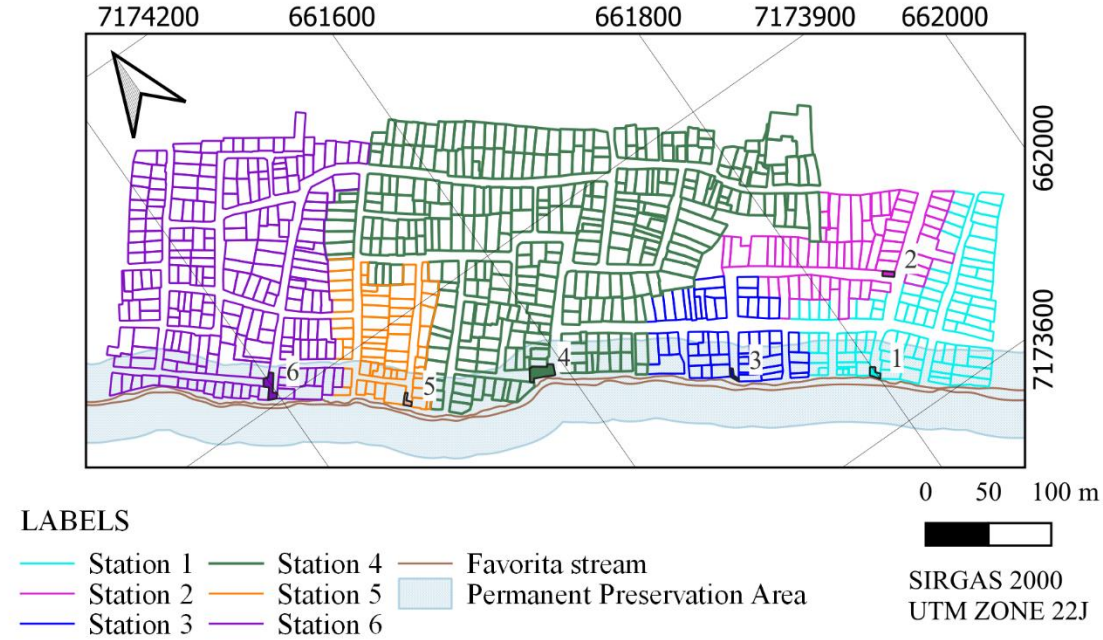

Figure 1 – Wastewater treatment plants and lots served by the systems

While decentralized systems offer an immediate solution for the community, transitioning to centralized systems should be considered for a more sustainable long-term approach as the community undergoes urban regularization. In the short term, decentralized systems remain essential for improving sanitation and protecting public health and the environment. These findings highlight the need of tailoring sanitation solutions to specific environmental, technical, and social contexts.

The framework developed in this work can serve as a valuable tool to guide decision-makers in identifying appropriate sanitation solutions for irregular settlements, particularly in urban areas with limited space and environmental vulnerabilities.

Although community consultation on the final solutions was not conducted in this work, it is recommended that future research includes community consultations to assess the acceptability and ensure the suitability of solutions before the final selection. Additionally, future studies should explore more adaptable and sustainable technologies, with collaboration between local governments and civil society organizations to ensure the successful implementation and scaling of such solutions.

ACKNOWLEDGMENTS

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

REFERENCES

Brazil. (2012). *Law No. 12.651 of May 25, 2012: Provides for the protection of native vegetation; amends Laws Nos. 6.938 of August 31, 1981, 9.393 of December 19, 1996, and 11.428 of December 22, 2006; repeals Laws Nos. 4.771 of September 15, 1965, and 7.754 of April 14, 1989, and Provisional Measure No. 2.166-67 of August 24, 2001; and provides other measures*. Federal Official Gazette, Brasília, DF, CXLIX(102), 1.

Burn, S., Shiroma, M., & Sharma, A. (2012). Utilising integrated urban water management to assess the viability of decentralised water solutions. *Water Science&Technology*, 66(1), p. 113-121.

Gomes, U. (2009). *Basic sanitation interventions in slum and favela areas: A comparative study of two experiences in the Metropolitan Region of Belo Horizonte* (Master's thesis). Federal University of Minas Gerais, Brazil.

Humanize Land Regularization and Social Urbanization (2022). *Contour and lot survey* [Data set]. Available upon request from Humanize Land Regularization and Social Urbanization.

Souza, L. (2019). *Basic sanitation in precarious settlements: A challenge to the universalization of services* (Master's thesis). University of Vale do Paraíba, Brazil.

Souza, C., Samora, P. (2022). Precarious urbanization: discontinuities and impacts of housing policies in consolidated settlements in the Metropolitan Region of Curitiba. *urbe. Brazilian Journal of Urban Management*, 14.

Tonetti, A., Brasil, A., Madrid, F., Figueiredo, I., Schneider, J., Cruz, L., ..., & Magalhães, T. (2018). *Domestic sewage treatment in isolated communities.* Campinas: UNICAMP.

Ribeiro, D., Nascimento, R., Mazzarotto, M., Petronzelli, L., & Leão, L. (2018). *ocioeconomic report Favorita 2018.* Araucária: TETO.