IWA 17th SWWS AND 9th ROS
10th–14th November, 2024
Curitiba-Brazil

Water reuse potential for agriculture: a GIS-based analysis of the Federal District.

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Highlights:

- Geospatial analysis to locate and choose suitable sites for agricultural reuse.
- Five watershed case studies: Melchior River, Sobradinho Stream, Upper Descoberto River, Ponte Alta River and Paranoá Lake.
- Georeferenced Information System containing the water withdrawal permits for irrigation, wastewater treatment plants, the location of vegetables and fruit tree irrigated areas.

Keywords: Agricultural Water Reuse; Restrict Irrigation; Geographic Information System.

INTRODUCTION

In Brazil, the Federal District (DF) experiences seasonal droughts lasting over four months and suffers from critically low per capita water availability (1,365 m³/inhabitant/year), ranking third lowest in the country (CODEPLAN, 2022). With a population of 2,817,068 and one of the highest demographic growth rates in the country (IBGE, 2022), the DF faced a significant water crisis between 2016 and 2018, largely driven by the addition of 470,000 residents between 2010 and 2017 (Lima, Freitas, Pinto & Salles, 2018 *et al*., 2018), with rapid urbanization increasing hydric stress in water bodies, especially during the dry season. Despite ongoing investments to enhance water supply capacity, there is an urgent need for alternative solutions, particularly non-conventional resources, to improve water efficiency and resilience. As consumption continues to rise, reclaimed water for agriculture presents a promising strategy to enhance water management, especially since agriculture is the sector most affected by water scarcity (Mancuso, Parlato, Lavrnić, Toscano & Valenti, 2022). DF's water bodies often lack sufficient flow to dilute and depurate effluents from wastewater treatment plants (WWTP), possibly leading to compromised water quality (Pinto Filho & Brandão, 2001), for this reason, water reuse becomes viable. Irrigated agriculture in the region reflects the tropical savanna climate, allowing the cultivation of a wide variety of vegetables and fruits all year-round, emphasizing: oranges, papayas, mangoes, guavas, passion fruits, bananas, strawberries (Monego *et al.,* 2013). Therefore, this paper aims to explore the potential for agricultural water reuse (AWR) in the Federal District using Geographic Information System (GIS) technology, a computer-based system used for storing, managing, manipulating, and analysing spatial data (Mancuso, Parlato, Lavrnić, Toscano & Valenti, 2022). This study prioritises water reuse in agricultural (fruit trees) and landscape irrigation, these types of schemes are known as direct and restricted water reuse.

METHODOLOGY

The data used to build the database were sourced from the District's Environmental Information System (SISDIA) or directly provided by the Technical Assistance and Extension Company (EMATER) and the Water, Energy, and Sanitation Regulatory Agency (ADASA). The study utilized GIS to identify potential areas for agricultural water reuse (AWR) by integrating WWTP shapefiles (SISDIA, 2023) with agricultural csv files, including irrigation site locations, crop types, cultivated areas, and annual production (EMATER, 2023), along with water withdrawal permit shapefiles (ADASA, 2023). All data were processed using a GIS software, and the map generation followed the steps outlined in the flowsheet shown in Figure 1.

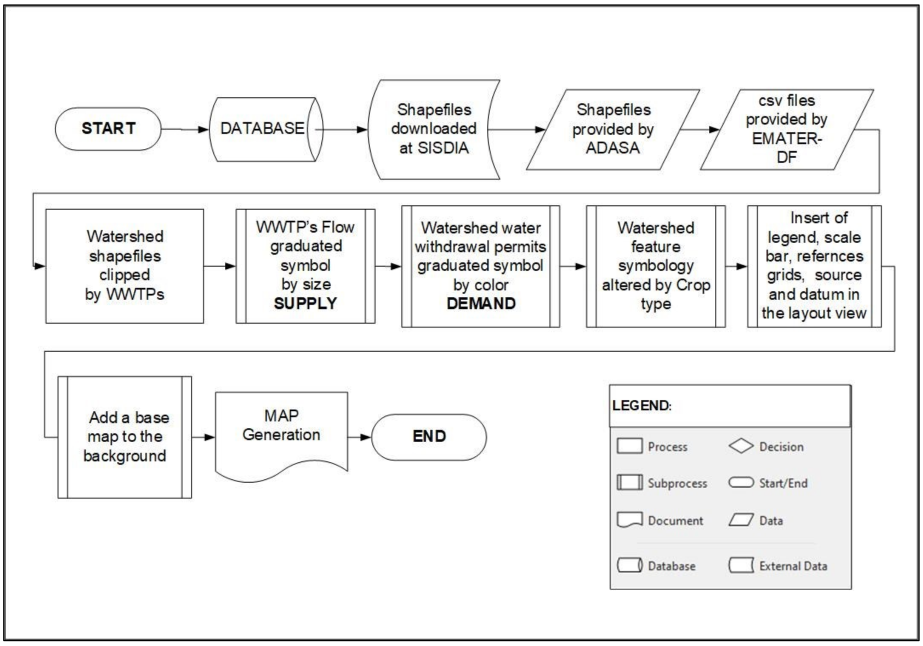

Figure 1 *- Flowsheet showing the step-by-step used to generate GIS-based maps to determine the potential for agricultural water reuse in the Federal District.*

The quantity and quality of the effluent, water quality guidelines (Brasil, 2023; EPA, 2012 & Regulation EU 741, 2020) and distribution costs were also considered in the AWR potential analysis. Effluent data from 2017 to 2022, provided by ADASA, included daily flows from eight WWTPs to calculate the average flow and water quality data such as: Biochemical Oxygen Demand (BOD_5), Total Suspended Solids (TSS), and *Escherichia coli* (*E. coli*) were assessed and compared with the mentioned guidelines. To determine the investments required for water reuse distribution, storage, and use, an elevation profile was generated for each WWTP, along with a Reuse Water Supply System (RWSS) scheme and its total length (ΔL). The system could either supply a specific community's demand or serve as a fill up point for water trucks. Investment Capital (CAPEX), Operation & Maintenance (OPEX) costs estimates were based on the Environmental Sanitation Company (CAESB) budget framework and the National System for Researching Construction Costs and Indices (SINAPI), including costs for construction sites, piping, excavations, pumps, motor control centres, pumping stations, and metal reservoirs. However, these issues will be addressed in other future technical works.

RESULTS AND CONCLUSIONS

The water budget between water supply and crop water demand for AWR is presented in the map in Figure 2, which includes the average daily flows of each WWTP (ℓ/s) classified by size. The five watersheds are color-coded based on the volume of water withdrawal permits for irrigation (ℓ/s). The Upper Descoberto River (UDR) exhibits the highest water demand for irrigation, approximately 23 times greater than the average daily flow of the Brazlândia WWTP (962 ℓ/s *versus* 42 ℓ/s). This significant difference suggests the feasibility of applying the zero effluent concept in that watershed, where no treated effluent would be discharged into surface water bodies in the future.

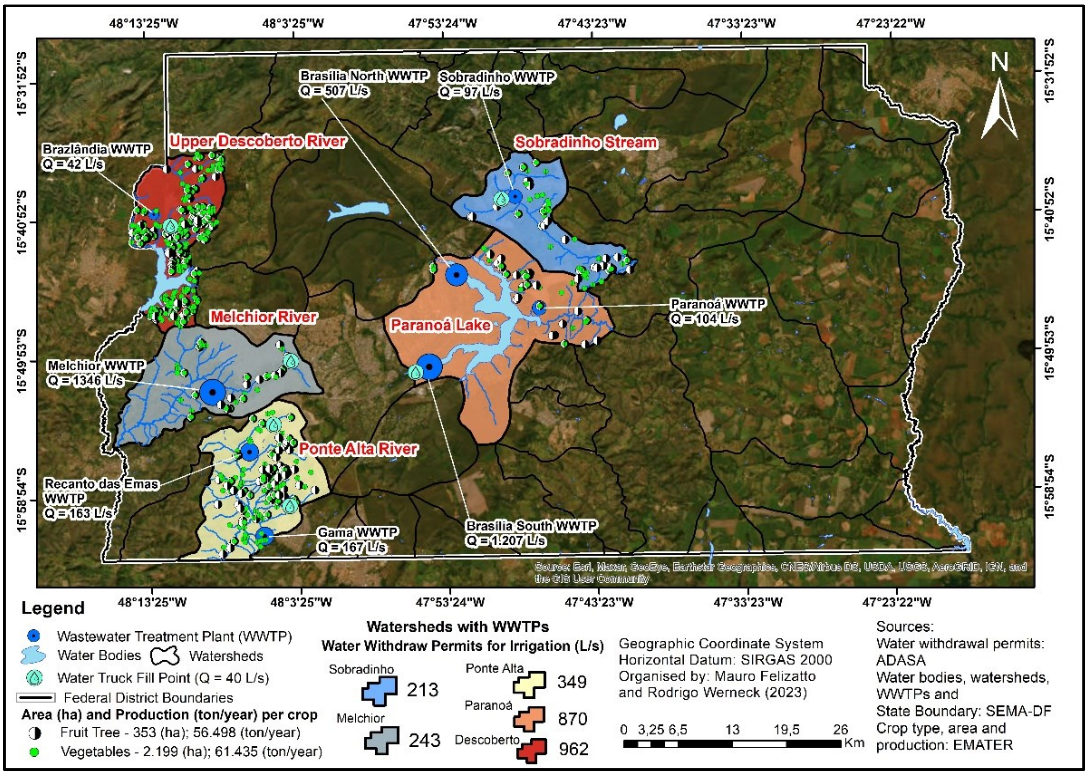

Figure 2 *– Study area showing the AWR potential based on the water budget between water supply and water demand, in addition to the spatial distribution of fruit tree and vegetables growers.*

When comparing the water quality of the WWTPs with guidelines, all stations showed values exceeding the limits for *E. coli* (3 log units), due to the absence of disinfection processes at the plants. The Brasília Sul and Gama WWTPs presented the highest treated water quality and could be used for landscape irrigation by implementing a disinfection unit and a RWSS to fill up water trucks. The other ones, Sobradinho, Melchior, and Brazlândia WWTPs would require final polish and disinfection unit to reduce BOD_5, TSS and *E. coli* concentrations to comply with the guidelines, 30 mg/ℓ, 30 mg/ℓ and 10^3 MPN/100 mℓ, respectively. Finally, cost estimates for RWSS schemes were conducted in the five watersheds to supply water to fruit tree and landscape irrigators. The estimated investment (CAPEX + OPEX) is about a million euros to transport 78 ℓ/s over from the WWTP to the irrigators, approximately 1,8% of the DF's total treated effluent (4,15 m^3/s).

ACKNOWLEDGMENTS

We would like to thank UNESCO/Brazil for the opportunity to carry out this work.

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