# Treatment Wetland as post-treatment for septic tank in decentralized system: Case study

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Highlights:

- Decentralized technologies can be the solution to the lack of sanitation, especially septic tank, which is widely used nowadays;
- Treatment Wetland, as a natural based solution, is an efficient and low-cost post-treatment for septic tanks;
- Efficient treatment aimed at reusing water in agriculture, mainly because it contains nutrients, such as nitrogen and phosphorus.

Keywords: Decentralized treatment; Treatment wetland; Agriculture reuse.

## INTRODUCTION

A large proportion of the Brazilian population (44.2%) does not have access to sewage collection and treatment (SNIS, 2021). One potential solution to this issue is the adoption of decentralized wastewater treatment technologies, either on an individual or collective level, to serve small communities, especially in rural areas. Among rural households in the country, 40.2% had a septic tank (ST) not connected to the network (IBGE, 2022), widespread mainly due to its simplicity and low cost. After the settling of the solids and decomposition of the accumulated solids by anaerobic digestion, in ST, the standard NBR 13969 (ABNT, 1997) recommends a post-treatment to dispose of the effluent.

Treatment wetlands (TWs) are engineered systems designed as a nature-based solution (NbS) that have been used as a decentralized form of ST post-treatment and show great potential for application in rural areas. They have relatively low operating and maintenance costs, operational simplicity and flexibility and pollutant removal rates that are considered efficient; however, they have limitations, such as dependence on the environment and the large area required, as well as being subject to clogging of the porous space (von Sperling et al., 2017). This study aims to analyze two real constructed wetland systems built on a small scale and their unique configurations, including septic tanks and TW.

## METHODOLOGY

The study was conducted based on the analysis systems implemented in households for decentralized domestic wastewater treatment, established in Farroupilha (F-DW) and Alto Feliz (AF-DW), cities in the state of Rio Grande do Sul, located in southern Brazil. The installations were carried out in 2016 (F-DW) and 2018 (AF-DW), and each household has four people. The systems are shown in Figure 1.

The wastewater is treated initially in a septic tank followed a TW. These TW employ gravel as the filtering material and feature *Canna indica L* as the primary vegetation (ornamental plants). The F-DW system utilizes horizontal subsurface flow, while the AF-DW system adopts a saturated vertical flow configuration. In both cases, the treatment efficiency was assessed through the analysis of various parameters: Chemical Oxygen Demand (COD), Ammoniacal Nitrogen ($NH_3$), Total Phosphorus (TP) and Total Suspended Solids (TSS). Data originate from the input and output values of TW.

*Figure 1: F-DW (left) and AF-DW (right) systems.*

The data were analyzed using the Shapiro-Wilk test, which indicated non-parametric distribution. Subsequently, the medians of the samples were employed alongside the quartile coefficient of variation, a robust statistical measurement and has been widely suggested as an alternative to the coefficient of variation for non-normal distributions a measure of relative dispersion. Compares the difference between the third and first quartiles to their sum, which values range are from 0 to 1, with 0 indicating no variability and 1 indicating maximum variability (Bonett, 2006).

## RESULTS AND CONCLUSIONS

The medians of the TW inlet and outlet concentrations and the quartile coefficient of variation are summarized in Table 1. The efficiencies of each parameter are shown in Table 2. The F-DW, and AD-DW systems achieved high rates of COD removal, with a COD efficiency of 87%. Similar results were found for COD with different vegetations: 76%, *Eichhorina sp.*; 80%, *Phragmites sp.* (Valipour *et al.*, 2014); 79%, *Typha sp.* (Ciria *et al.*, 2005). The significantly higher removal rates of COD indicate that the plants functioned in  removal (Oliveira *et al.*, 2021). The removal values for TSS accordance with the literature, where an efficiency of 80% (von Sperling *et al.*, 2017).

| | COD (mg.L$^{-1}$) | | $NH_3$ (mg.L$^{-1}$) | | TP (mg.L$^{-1}$) | | TSS (mg.L$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|
| | Inlet | Outlet | Inlet | Outlet | Inlet | Outlet | Inlet | Outlet |
| F-DW | 995 (0,23) | 97,0 (0,40) | 166,2 (0,38) | 44,18 (0,12) | 30,14 (0,18) | 9,84 (0,24) | 303 (0,59) | 40,0 (0,24) |
| AF-DW | 866 (0,21) | 99,4 (0,43) | 132 (0,17) | 71,9 (0,47) | 30,1 (0,07) | 26,4 (0,14) | 250 (0,30) | 60,0 (0,37) |

*Table 1: Median values of each parameter at inlet and outlet and the quartile coefficient of variation.*

| | COD | NH3 | TP | TSS |
|---|---|---|---|---|
| F-DW | 90,2% | 73,4% | 67,3% | 86,8% |
| AF-DW | 88,5% | 45,6% | 12,2% | 76,0% |

*Table 2: Removal efficiency of treatment wetlands.*

The AF-DW system show the lowest phosphorus removal (12%), according to von Sperling et al. (von Sperling *et al.*, 2017) the removal efficiency is 10-20% (vertical flow). This low efficiency may be due to the filter material, gravel, has a very limited adsorption capacity, and, furthermore, a low removal by plants (Stefanakis *et al.*, 2014). $NH_3$ showed high input concentrations in the domestical systems, despite achieving removal rates of 73.4% and 45.6%, but still high loads, > 40 mg.L$^{-1}$. The output values for nutrients remain high and are not suitable for disposal directly into water resources. However, it can be used for other purposes such as toilet flushing and agricultural irrigation, as it often uses not only the water but also the nutrients present in it and avoids the disposal of N and P, which are responsible for eutrophication problems (Brazil, 2017; Oliveira *et al.*, 2021).

The two decentralized (onsite) systems (F-DW and AF-DW) have many peculiarities, presenting different flows, effluents, macrophytes, and local environment features. But fulfilled the objective of making the effluent suitable for disposal in nature. This underscores their potential as a promising technique for decentralized systems, particularly in rural areas, where water treated by TW systems can be utilized for agricultural irrigation and gardening without adverse effects.

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