# Influence of artificial aeration on the removal of organic matter and nutrients in a tidal flow constructed wetland system

Bernardelli, J. K. B.*, Svenar, S.*, Pedro, B. L.**, Rosa, A.*** and Passig, F. H.****

*The Federal University of Technology - Paraná (UTFPR), Environmental Sciences and Technology Graduate Program, Deputado Heitor de Alencar Furtado St., 5000, Ecoville, 81280-340, Curitiba, Paraná, Brazil. Email: Silvana.svenar@gmail.com.

**Federal University of Technology - Paraná (UTFPR) - Civil Engineering Graduate Program, Deputado Heitor de Alencar Furtado St., 5000, Ecoville, Curitiba, Paraná 81280-340, Brazil. Email: jossybernardell@utfpr.edu.br; beatrizlarissa@alunos.utfpr.edu.br.

***Pontifical Catholic University - Paraná (PUCPR), Civil Construction Academic Department, Imaculada Conceição St., 1155, Prado Velho, 80215-901, Curitiba, Parana, Brazil. altair.rosa@pucpr.br.

****Federal University of Technology - Paraná (UTFPR) – Chemistry and Biology Academic Department, Deputado Heitor de Alencar Furtado St., 5000, Ecoville, Curitiba, Paraná 81280-340, Brazil. Email: fhpassig@utfpr.edu.br.

**Highlights:**

- The removal of organic matter is not affected by the insertion of artificial aeration;
- The insertion of aeration promoted the intensification of the nitrification process;
- Phosphorus removal had an increase of more than 20% after the insertion of artificial aeration.

**Keywords:** Intensification of nitrification; construction waste; adsorption, precipitation and biodegradation processes.

## INTRODUCTION

The tidal flow constructed wetlands (TFCW) is a proposal to optimize traditional CW, which aims to improve the removal of organic pollutants and nutrients. The flooded and drained/rest periods of these systems increase oxygen transfer in the environment and alter between aerobic, anaerobic, and anoxic conditions, favoring the physical, chemical, and biological mechanisms that promote the removal of pollutants (Cheng et al., 2021; Dotro et al., 2017; Chen et al., 2016). Studies have investigated alternative support materials with adsorption capacity to improve total phosphorus removal efficiency in CW systems (Roth et al., 2021; Han et al., 2019; Tan et al., 2019).

## METHODOLOGY

The system is composed of the influent reservoir (310 L), TFCW (117 L) vegetated with *Alternanthera philoxeroides* (Mart.) Griseb. onto red ceramic fragments, an effluent reservoir, and an aeration tank (120 L) (Figure 1). Three electric pumps carried out the filling (descending subsurface), drainage, and recirculation stages (Consul, model W10849469). The dimensions of the TFCW, the textural and morphological properties of the filtering material, the filling and drainage pipes, the sampling columns, the monitoring well, and the composition of the synthetic effluent were detailed by Roth et al. (2021).

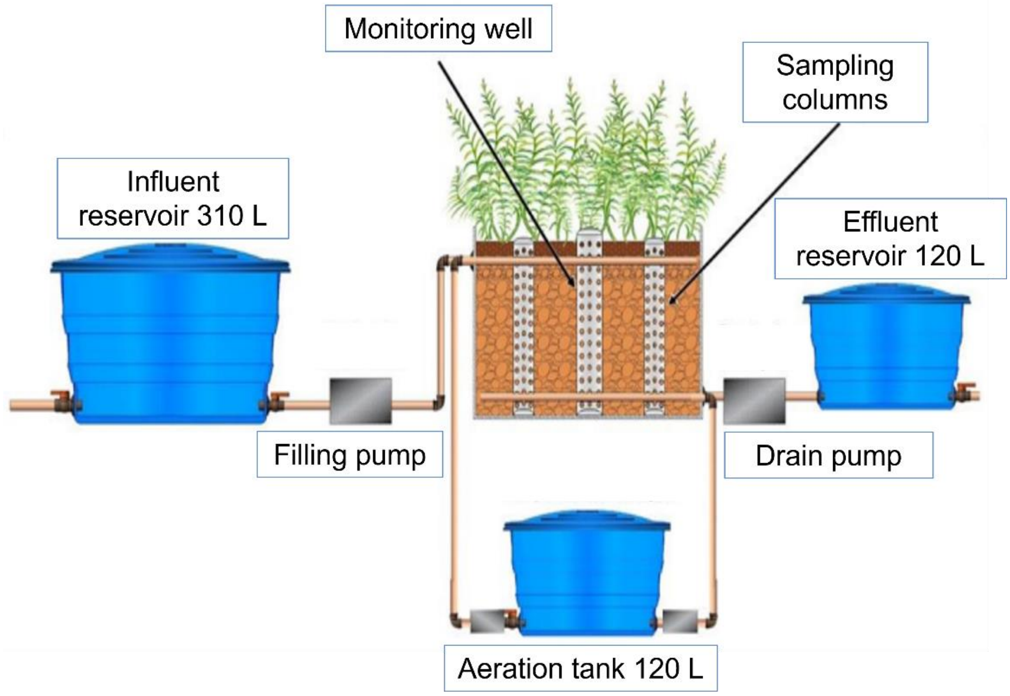


Figure 1 - Schematic representation of the tidal flow constructed wetland (TFCW)

The operation was carried out in two stages; in the first stage, the flooding and rest periods were carried out in a single tide; the TFCW remained flooded for 48 hours. After, the effluent was drained from the system, which remained empty for 12 hours until the next cycle (CI). In the second stage, the system was operated with two tides, starting with a flooded time of 48 h, followed by artificial aeration of the effluent in an external tank for 3 hours (TFCW remained empty). Subsequently, the aerated effluent was recirculated into the system, remaining for 9 hours, and then discarded (CII). Physicochemical parameters chemical oxygen demand (COD, mg $L^{-1}$) (5220 D), Total Kjeldahl Nitrogen (TKN, mg $L^{-1}$) (4500-Norg D), Total ammonia nitrogen (TAN, mg $L^{-1}$) (4500-$NH_3$ C), Total Phosphorus (TP, mg $L^{-1}$) (4500-P E) were determined in the influent and effluent samples in duplicate (APHA, 2017).

## RESULTS AND CONCLUSIONS

The average COD values for the influent and effluent were 349 ± 72 mg $L^{-1}$ and 40 ± 14 mg $L^{-1}$, 238 ± 20 mg $L^{-1}$ and 16 ± 1.9 mg $L^{-1}$, representing removal efficiencies of 88% and 93% in CI and CII, respectively (Figure 2). Several studies on TFCW systems showed high COD removals, as found in this study. The authors attributed the removal efficiencies mainly to the adsorption process of the carbonaceous matter to the support material, operational regime and influent COD concentrations (Xu et al., 2021; Roth et al., 2021; Lião et al., 2022). By comparing these results, the artificial aeration and effluent recirculation, simulating multiple tides, improved the removal of this parameter.

The average TKN values were 44 ± 12 mg $L^{-1}$ and 22 ± 3 mg $L^{-1}$ in the influent, resulting in 60% and 81% removal efficiencies in CI and CII, respectively (Figure 2). TAN presented average concentrations of 30 ± 8 mg $L^{-1}$ and 14 ± 0.8 mg $L^{-1}$ in the influent in CI and CII, respectively, with 57% and 98% removal efficiencies (Figure 2). The results indicated that the artificial aeration and effluent recirculation enhanced the removal of these nitrogen forms. $NH_4^+$ ions are adsorbed onto the surface of the support material negatively charged during the flooded period, while the air is drawn into the pores of the support material, causing nitrification during the drained period (Hu, Zhão, and Rymszewecz, 2014; Roth et al., 2021). Therefore, tides and artificial aeration positively influenced the removal of TKN and TAN, intensifying the nitrification process by the increased availability of DO.

The average TP was 13.6 ± 2.2 mg $L^{-1}$ and 8.5 ± 1.3 mg $L^{-1}$ in the influent in CI and CII, respectively, achieving removal efficiencies of 63% and 87% (Figure 2). The recirculation and oxygenation of the effluent in CII favored the removal of total phosphorus, as in addition to providing more cycles of adsorption and regeneration of the support material, it may have provided the precipitation of TP by ferric ions (Hu, Zhão and Rymszewecz, 2014).

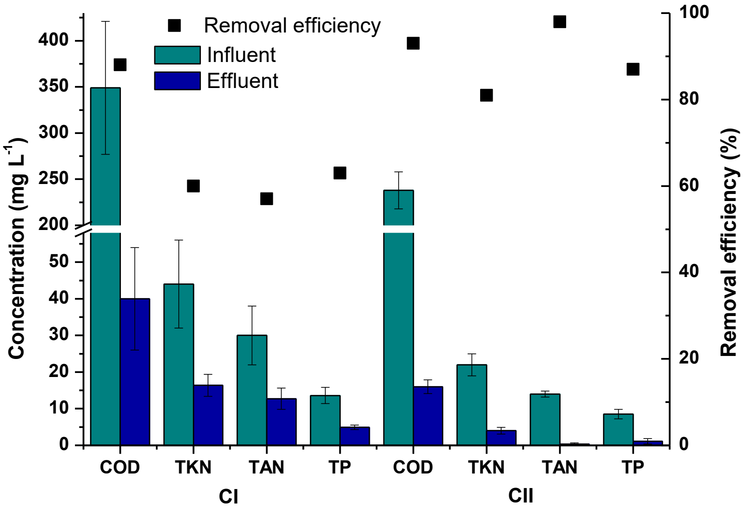


Figure 2 – Concentrations of COD, TKN, TAN and TP in the influent and effluent samples in TFCW and removal efficiency for both stages, CI and CII (n = 8).

## ACKNOWLEDGMENTS

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