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Performance of tidal flow constructed wetland used for organic matter and nitrogen removal

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Highlights:

- Aeration was evaluated for organic material removal.
- N-ammonium was not removed efficiently.
- WC tidal flow provided a satisfactory reduction in chemical oxygen demand.
- WC tidal flow is a promising and sustainable solution for reducing organic matter in water bodies.

Keywords: Constructed wetland. Organic matter removal. Tidal flow.

INTRODUCTION

The main impacts on water resources stem from the emission of pollutants and nutrients through sewage discharge and improper disposal of solid waste on land (Vliet et al., 2021).

Considering the importance of water for sustaining life on Earth, it is necessary to adopt actions and utilize remediation technologies aimed primarily at restoring socio-environmental security and improving the quality of water resources. Constructed wetlands (CW) are one of the alternatives identified, representing controlled artificial systems comprising components such as substrates, aquatic plants, and microorganisms (Dotro et al., 2017).

In the literature, constructed wetland (CW) configurations are not only studied for effluent treatment and the mitigation of urban water degradation but also for their practical application in enhancing microbial activities and improving treatment performance. To improve this efficiency, various oxygenation technologies have been developed, such as tidal flow, which simulates flood and ebb cycles, increasing oxygen exchange and enhancing treatment (Li et al., 2021).

This study aims to analyze the feasibility of constructed wetlands with tidal flow under laboratory-scale conditions for organic matter removal in synthetic media simulating an urban river in Fortaleza, Ceará.

METHODOLOGY

The constructed wetland was fabricated in a polypropylene box with dimensions of 0.23m x 0.29m x 0.41m, with a volume of 20 liters, consisting of layers of gravel and bricks. The tidal flow constructed wetland operation occurred in batches, considering operation cycles of 48 and 72 hours. The system was fed synthetic media and operated for 72 hours. Then, the system was drained and remained empty for 24 hours. After this period, the system was fed with synthetic media again and operated for 48 hours. Subsequently, the system was drained and remained empty for 24 hours. The system's operation lasted

for 29 days following the abovementioned feeding/operation/drainage procedure. It is worth noting that the drainage occurred to allow the filling of oxygen from the atmosphere into the empty spaces between the pores of the filter bed when the liquid was drained entirely, thus increasing the reoxygenation capacity and oxygen transport in the constructed wetland.

The macrophyte, *Echinodorus subalatus*, was chosen based on Bermúdez (2022) work and was acquired from the Environmental Technology Laboratory of IFCE and the adaptation time of the species in the nutrient medium lasted 54 days.

It was necessary to perform physicochemical characterization to produce synthetic media simulating the Cocó River. The chosen point for the study is located at the geographic coordinate's latitude 553161 m E and longitude 9577293 m S. This choice was based on the strategic importance of its location, as it is under the influence of the former landfill of Fortaleza.

In feeding the constructed wetland system, synthetic media with low concentrations of carbonaceous matter (Chemical Oxygen Demand < 250 mg/L) were used, considering the results obtained from the characterization of the Cocó River. For system monitoring, pH, COD, and ammonia parameters were analyzed in the influent and effluent of the CW system.

RESULTS AND CONCLUSIONS

The results of the COD analyses demonstrated reductions in the parameter, as the influent concentration in the tidal wetland system had an average of 143.26±40.63 mg/L, and the concentration relative to the treated sample had an average of 8.46±11.6 mg/L, resulting in an average percent removal of 94.46%±0.08%.

Roth et al. (2021) achieved satisfactory results in COD removal (60% to 80%) using a 12-hour resting period in tidal flow CW systems. Similarly, Luzhen et al. (2015) operated tidal flow CW systems with flooding times ranging from 12 to 48 hours, obtaining efficiencies ranging from 77% to 94%, with the best removals occurring within the first 18 hours of flooding.

The ammonia nitrogen (NH_4-N) analyses showed low removals of the parameter. The NH_4-N concentrations in the influent had an average of 40.93±2.11 mg/L, and the concentration relative to the treated sample had an average of 23.39±8.46 mg/L, resulting in an average percent removal of 42.79%±0.2.

Bermúdez (2022) also identified that NH_4-N was not significantly removed in the treatment of synthetic gray water with the macrophyte *E. subalatus*, concluding that a pH below 6.0 would have interfered with the processes of ammonia-oxidizing bacteria, resulting in the inhibition of the nitrification phase, as these bacteria require a pH range of 7 to 9 for their growth (Ward et al., 2011). Similarly, in this study, the pH remained below 7 (6.4±0.1), which could be one of the interfering factors in reducing the evaluated parameter.

Overall, the tidal flow constructed wetland system demonstrated high COD removal efficiency, highlighting the success of the oxygenation strategy. However, the results for ammonia nitrogen (NH4-N) were less satisfactory, likely due to the pH not being within the ideal range for nitrification, which is typically between 7.0 and 9.0.

In conclusion, the tidal flow constructed wetland proved to be a promising and sustainable solution for reducing organic matter in water bodies. The interaction between microorganisms, plants, and substrate played a key role in facilitating the degradation of organic matter.

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