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VERMIFILTRATION AS A POTENTIAL SOLUTION FOR DECENTRALIZED TREATMENT OF WASTEWATER FROM SOURCES WITH SEASONAL VARIATION

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Introduction

Vermifiltration is an innovative and sustainable approach to wastewater treatment that leverages the natural filtering and decomposition abilities of earthworms. The filter bed typically consists of layers of organic media such as soil, sand, and gravel, through which the wastewater percolates. Earthworms and associated microbes create a synergistic environment for treating pollutants. Earthworms, specifically species like *Eisenia fetida* (red wigglers), play a central role in breaking down organic matter in wastewater. Their burrowing actions increase aeration, allowing microorganisms to further degrade organic pollutants. For sources with seasonal variation, such as cottages, tourist accommodations, and other facilities with fluctuating populations, vermifiltration offers a decentralized solution that addresses the challenges associated with wastewater management. The present study focusses on the capacity of an earthworm system to cope with intermittent feeding with influent wastewater.

Materials and methods

The experimental setup includes five bioreactors operated in parallel to allow the collection of reliable data to validate the experimental model. Each of the five bioreactors has a total capacity of approximately 50 L and a surface area of 0.01 m² to ensure representative conditions. The experiments were conducted under conditions where synthetic wastewater with known characteristics was used, specifically: 510±30 mg/L COD_{Cr}, 310±20 mg/L BOD₅, 55±5 mg/L NH₄⁺, 7.5±2 mg/L total phosphorus (P_{tot}). Various nutrient loading rates were tested to cover a wide range of operational scenarios. Additionally, the inclusion of stress tests, such as unexpected interruptions in wastewater supply for 1 week, adds a level of realism that allows for the evaluation of the system's resilience and recoverability.

The testing plan aimed to obtain a set of relevant data on the system's performance under different operating conditions, specifically: assessing treatment performance at different influent flow rates (equivalent to 480 L/m²day for installations 1 to 3, and 240 L/m²day for installations 4 and 5, corresponding to nutrient loading rates of approximately 120-240 g COD_{Cr}/m²day and 13-26 g N-NH₄⁺/m²day, respectively); evaluating the impact of no feed scenario (1 week) on treatment performance.

Results and conclusions

The experimental results for all five experimental installations are presented graphically in Figures 1, highlighting the trend of contaminant removal efficiency.

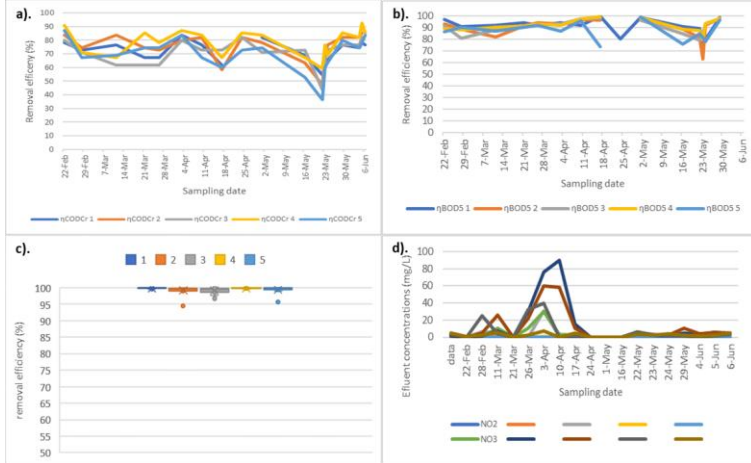


Figure 1. Variation of organic load removal efficiency expressed as COD_{Cr} (a), expressed as BOD₅ (b), mean ammonium removal efficiency (c) and remaining oxidized nitrogen forms concentrations (d)

The COD_{Cr} concentrations are significantly reduced in the effluents of the 5 installations, corresponding to average removal efficiencies ranging between 60% and 70% for total COD_{Cr} and between 70% and 85% for dissolved COD_{Cr}. Installations 4 and 5 show the most consistent treatment performances and highest average efficiencies. No feed strategy of one week temporarily impacted the treatment efficiency in some installations, indicating a moderate impact of these periods on treatment performance. However, this effect is temporary, and the organic load removal efficiencies returned to the typical range for vermifilters, approximately 70-80% for organic load removal expressed as COD_{Cr}. The biodegradable organic load, expressed as BOD₅, is significantly reduced, with removal efficiencies of up to 99%. Most values are around 90% efficiency, indicating good microbiological activity in removing the biodegradable organic load. The simulated "no-feed" scenario impacted moderately the BOD₅ removal efficiency, and it quickly returned to initial performance once feeding was resumed. Vermifiltration systems can be designed to accommodate varying levels of wastewater input. During off-peak seasons when flow rates are lower, the system can operate efficiently at reduced capacity. On the other hand, during peak tourist seasons, these systems can easily recover the treatment capacity and handle higher loads due to their capacity to process variable quantities of organic matter. Thus, vermifiltration is a promising solution for the decentralized treatment of wastewater in locations with seasonal variations in population.

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