

Treatment of raw mixed dairy wastewater using an attached-growth biological filter

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INTRODUCTION & AIM

Reckless disposal of untreated dairy wastewater into natural water bodies leads to severe ecological consequences, including aesthetic degradation and the destruction of aquatic ecosystems. Wastewater originating from dairy processing activities, such as second cheese whey and pudding dessert production lines, is typically characterized by high concentrations of organic matter and suspended solids, and elevated salinity, often accompanied by acidic pH values. In addition, this wastewater contains significant amounts of nitrogen and phosphorus. The uncontrolled discharge of such nutrient-rich effluents into lakes and rivers accelerates eutrophication process. Biological treatment technologies represent a promising and sustainable solution, offering high removal efficiencies for both organic and inorganic pollutants, while reducing energy demand and operating costs compared to conventional methods. The present study examined the biotreatment of dairy wastewater with an attached-growth filter of indigenous bacteria to reduce organic and nutrient loads.

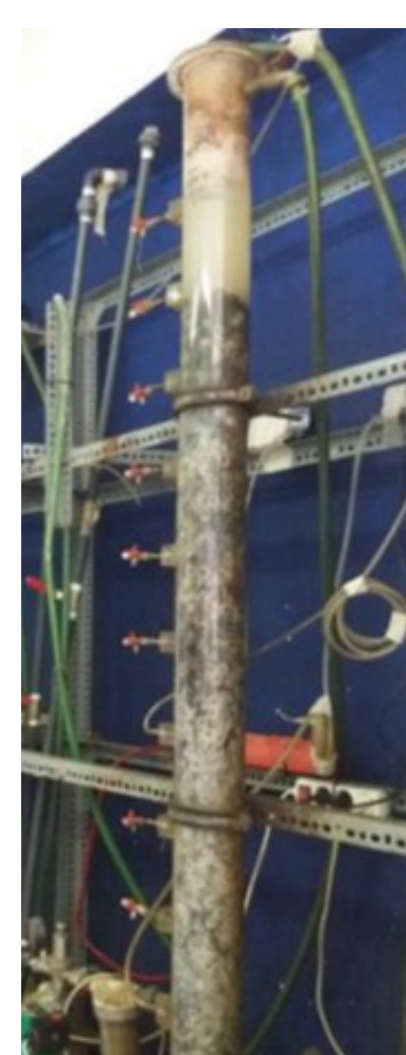
METHOD

The pilot-scale attached-growth bioreactor

- Plexiglass vertical tube
- Height : 160 cm
- Internal diameter : 9 cm
- Volume : 10.1 L (working volume 7.0 L)
- Support media : hollow plastic tubes (0.8 filter porosity)

Experimental set-up

- Non-sterilized conditions
- Room temperature (24 ± 1 °C)
- Continuous aeration
- Batch operation (SBR) with recirculation 1.0 L/min



RESULTS & DISCUSSION

In all experimental cases wastewater comprised a 1:1 mixture of second cheese whey and traditional pudding effluent. Dilution with tap water produced five distinct influent d-COD concentrations. The observed d-COD removal efficiency (Fig 1a) ranged from 81.4% to 92.3% at an initial concentration of about 2,500 mg d-COD/L. The maximum d-COD degradation rate (Fig 2b) was 194.6 mg/(L·h), achieved at an initial concentration of about 5,500 mg d-COD/L within an operating cycle of 20 h, thereby defining the reactor's optimal operating condition.

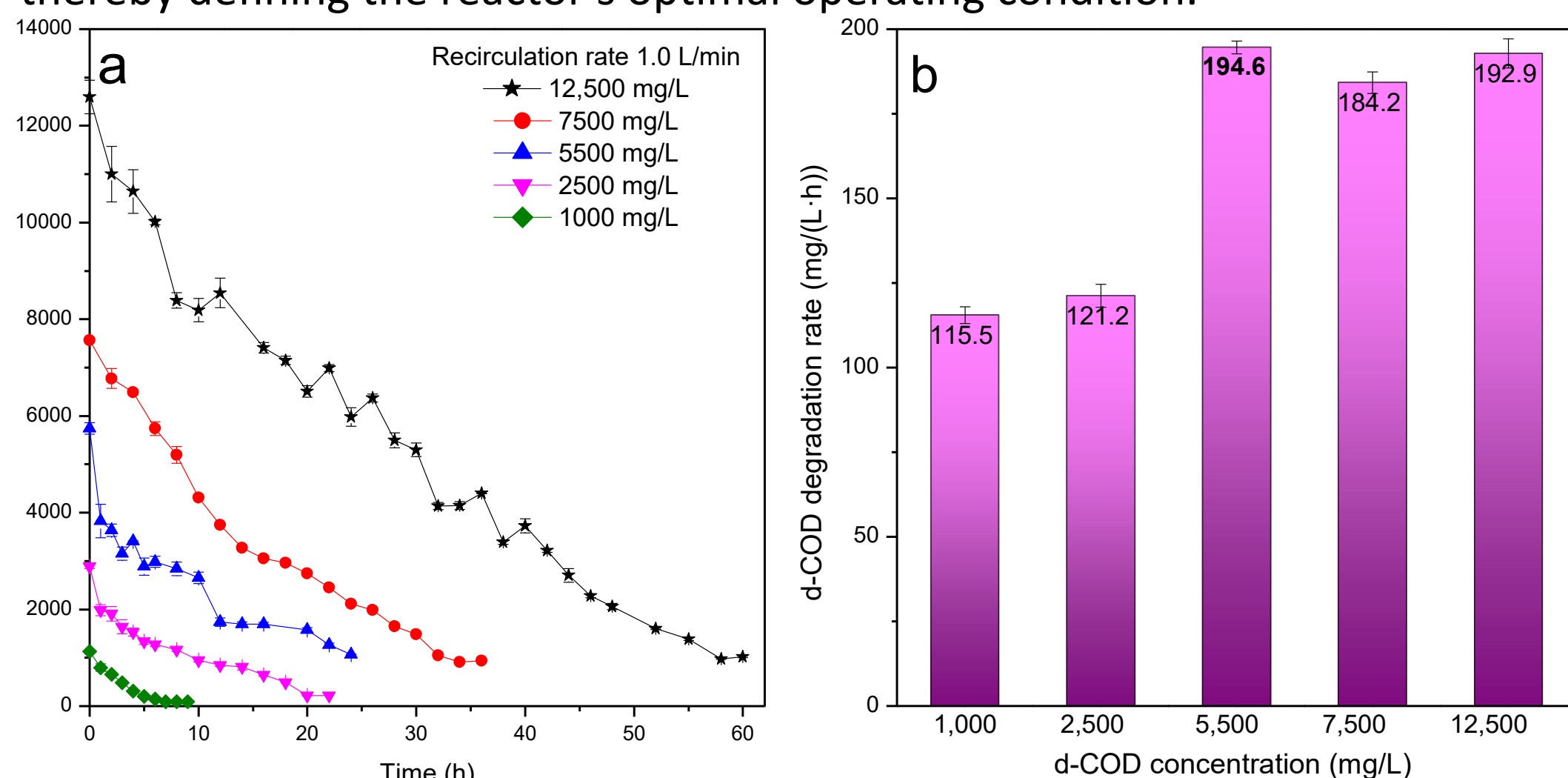


Figure 1. a) d-COD concentration in the biofilter operating in SBR with recirculation of 1 L/min and b) d-COD degradation rates at different influent d-COD concentrations.

RESULTS & DISCUSSION

For an influent concentration of 5,500 mg/L, high removal efficiencies were obtained for all examined pollutants. Specifically, d-COD and sugars were reduced by 81.4% and 98.5%, respectively (Fig 2a). Nitrate-N (NO_3^- - N) and ammonium-N (NH_4^+ - N) removals reached 60.3% by 92.9% (Fig 2b), confirming the high biodegradability of sugars and ammonium by indigenous dairy microorganisms. Orthophosphate removal was comparatively lower (44.5%), whereas total Kjeldahl nitrogen (TKN) achieved 94.2% removal (Fig 2c). Total dissolved solids (TDS) and total suspended solids (TSS), were reduced by 89.6% and 91.2%, respectively (Fig 2d). Furthermore, salinity analysis of filtered samples indicated an almost complete removal of salt at the end of the experiment.

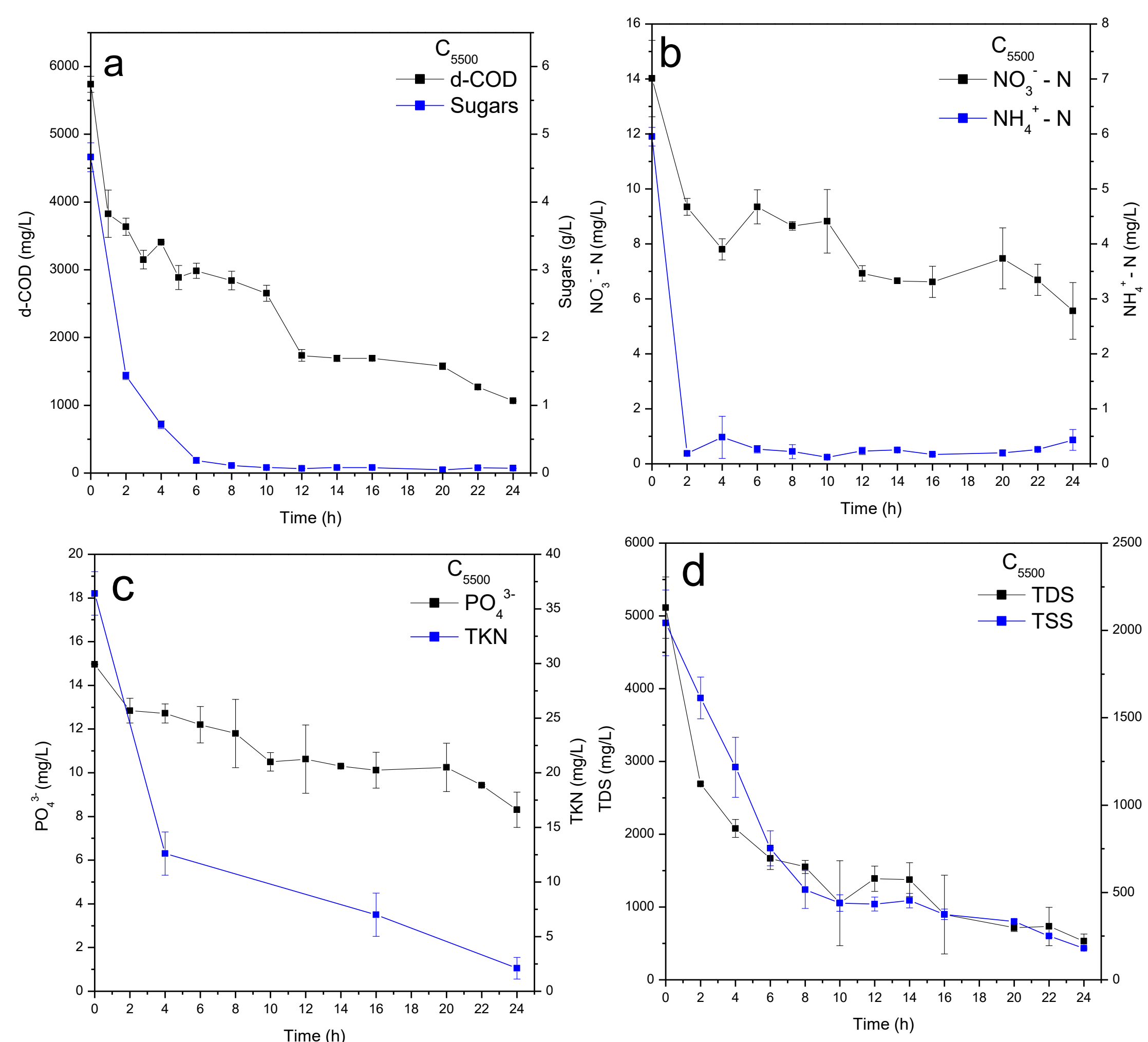


Figure 2. Concentrations of a) d-COD and sugars, b) NO_3^- - N and NH_4^+ - N, c) PO_4^{3-} and TKN, d) TDS and TSS in the pilot-scale biofilter operating under SBR mode for the initial d-COD concentration of 5,500 mg/L for recirculation rate of 1.0 L/min.

CONCLUSION

The attached-growth biofilter demonstrated consistently high efficiency in removing both organic and inorganic components for all tested influent organic loads, including the extreme concentration of 12,500 mg d-COD/L. This approach can therefore be proposed as a pre-treatment step, to be subsequently combined with electrochemical, physicochemical, or biological processes for more comprehensive treatment outcomes.

FUTURE WORK / REFERENCES

Future research should address appropriate post-treatment strategies to enable the safe disposal or potential reuse of mixed dairy wastewater, for instance as a substrate for cyanobacterial cultivation.

- 1) S. Patsialou et al, Hybrid treatment of confectionery wastewater using a biofilter and a cyanobacteria-based system with simultaneous valuable metabolic compounds production. *Algal Research*. 2024;79:103483. <https://doi.org/10.1016/j.algal.2024.103483>
- 2) S. Patsialou et al, Biological Treatment of Second Cheese Whey Using Marine Microalgae/Cyanobacteria-Based Systems. *Engineering Proceedings*. 2024; 81(1):4. <https://doi.org/10.3390/engproc2024081004>