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Denitrification aided by waste beer in anaerobic sequencing batch biofilm reactor (AnSBBR)

Artur Mielcarek[a], Joanna Rodziewicz[a,*], Wojciech Janczukowicz[a], Tomasz Dulski[b], Slawomir Ciesielski[b], Arthur Thornton[c]

[a] University of Warmia and Mazury in Olsztyn, Department of Environment Engineering, Warszawska St. 117a, Olsztyn 10-719, Poland
[b] University of Warmia and Mazury in Olsztyn, Department of Environmental Biotechnology, Słoneczna St. 45g, Olsztyn 10-709, Poland
[c] Atkins, Woodcote Grove, Ashley Road, Epsom KT18, United Kingdom

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ABSTRACT

The goal of research was to examine waste beer as a source of carbon in an anaerobic sequencing batch biofilm reactor (AnSBBR). It was demonstrated that waste beer enhanced denitrification. Observed biomass yield coefficient (Y_{obs}) was one size of magnitude lower than for suspended-biomass reactors (0.03 ± 0.03 mgTSS mgCOD^{-1}). The kinetic parameters (utilization of organic substrate and denitrification rates) were lower during the start-up period (88.8 mgO_2 L^{-1} h^{-1} and 17.37 mgN L^{-1} h^{-1}, respectively) than during stable operation of the reactor (212.4 mgO_2 L^{-1} h^{-1} and 34.66 mgN L^{-1} h^{-1} after 180 cycles). The metagenomic results showed that the abundance of *Alcaligenes* decreased from 18.39% to 0.88% (in 180 cycle), whereas the read numbers of *Trichococcus* increased gradually from 2.93% to 52.26% (in 180 cycle). *Trichococcus* was the dominant microorganism (52.3%). The low value of Y_{obs} most likely resulted from the ability of *Trichococcus* to degrade complex organic compounds and extracellular polysaccharide substances (EPS), released from dead cells in deeper layers of the biofilm.

1. Introduction

Denitrification and biological dephosphatation depend on the presence of organic compounds easily assimilable by microorganisms. One solution used in wastewater treatment plants is the introduction of an external organic carbon source to achieve a suitable C:N:P ratio. For wastewater treatment plant operators, the presented solution should enable efficient denitrification at the lowest possible biomass yield coefficient (Y_{obs}).

Recent studies on a sequencing batch biofilm reactor (SBBR) indicated that this solution could be used for effective denitrification and biological dephosphatation (Mielcarek et al., 2015a,b). Sequencing batch biofilm reactors are superior to systems with activated sludge because of their greater resistance to changes in pollutant loads, the presence of toxic substances and more compact design. In addition, biofilm reactors are also characterized by a lower biomass growth and better sedimentation properties of biofilm compared to activated sludge flocs (Helness and Qdegaard, 2001; Wilderer et al., 2001).

Considering the economic and environmental aspects, the use of wastewater characterized by a high C:(N + P) ratio as an external source of organic carbon appears to be the best solution. Wastewater discharged from breweries is highly biodegradable and has a high (over 25) ratio of BOD:(N + P). Among these products, beer after the best-before date, as well as beer discarded during quality control, is particularly noteworthy. Breweries classify such products as waste. Discarded beer can be used as an organic carbon source during the biological removal of nitrogen and phosphorus (BNR). A stream of wastewater with the best parameters for enhancing BNR can be separated from a specific production department, while beer unsuitable for consumption can be easily transported (Mielcarek et al., 2013; Janczukowicz et al., 2013).

Considering the advantages of biological film, it seems reasonable to use biofilm reactors for denitrification. However, the implementation of this solution requires a prior understanding of many aspects of the process. One of them is the kinetics of contaminant removal by microbial communities forming the biofilm (Hallin et al., 2006; Osaka et al., 2006). This study was designed to obtain novel information about microorganisms forming the biomass, and changes in the whole microbial community during the process. The identification of bacteria responsible for denitrification in a reactor

* Corresponding author.
E-mail address: joanna.rodziewicz@uwm.edu.pl (J. Rodziewicz).

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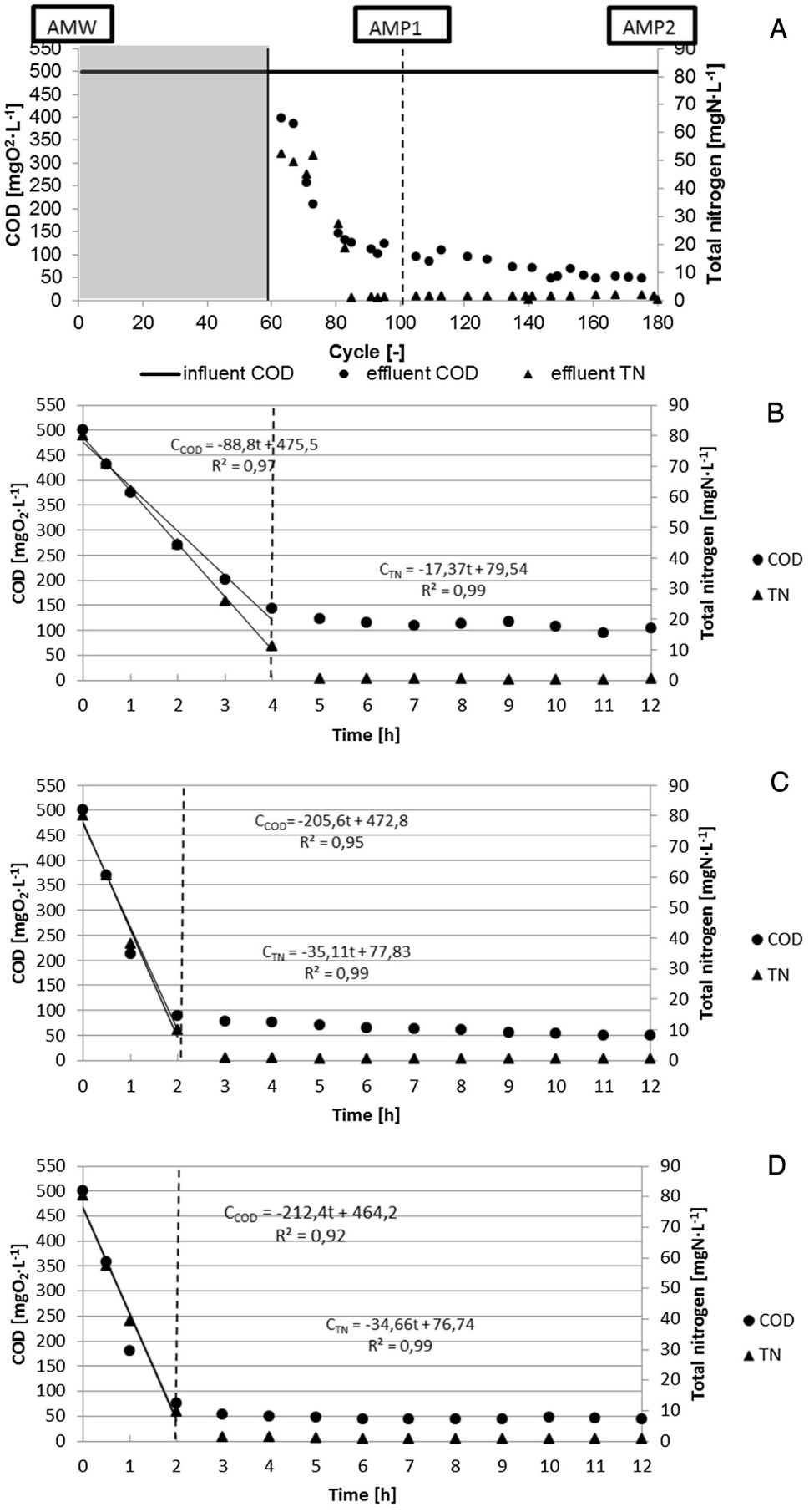

Fig. 1. A – changes in COD and total nitrogen during the tests; AMW, AMP1, AMP2 – collection of biofilm samples for microbiological analysis; B–D – tests on the kinetics of utilization of waste beer and denitrification after 100, 140 and 180 cycles of operation.