Elimination of Nitrate in an Inverse Fluidized-Bed Biofilm Rector

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This study is aimed at investigating the feasibility of an inverse fluidized-bed biofilm reactor to eliminate nitrate from water and wastewater using acetate as an external carbon source.

Methods

The experimental work was carried out in an inverse fluidized-bed biofilm reactor packed with a floating carrier as the support for biomass growth in which the continuous liquid phase (influent + recirculated effluent) was flowing downward countercurrent to the gas phase. The carrier (33% v/v) was an irregular plastic granular product with grain size in the range of 1–3 mm and an average density of 865 kg m^{-3}. The bioreactor was fed continuously with increasing nitrate concentrations in a synthetic medium of tap water, potassium nitrate and sodium acetate, maintaining the C/N mass ratio at 3.5. Phosphate ($-PO_4^{3-}$) was supplied at a concentration of 3.5 mg L^{-1}. For each nitrate concentration the reactor was operated until steady state conditions were achieved.

Nitrate, nitrite and chemical oxygen demand (COD) analyses in liquid samples were in accordance with those outlined in Standard Methods. The biofilm mass was estimated by means of dry weight (103–105 °C), total protein (Sigma kit) and total polysaccharides (Dubois method).

Results and Conclusions

The maximum nitrate removal rate reached in this study was 2.98 $kg_{N\text{-}NO3^-}$ m^{-3} d^{-1}, which is higher than those obtained with submerged filters[1]. The maximum quantity of nitrate consumed divided by the amount of biofilm dry weight (DW) in the reactor was 0.45 $kg_{N\text{-}NO3^-}kg^{-1}{}_{DW}$ d^{-1}, which is of the same order as those obtained with fluidized-bed reactors[2]. The consumed COD/N mass ratio was about 8.1. No nitrite accumulation was observed.

Biofilm dry weight steady state values were nearly constant (6.1→6.6 kg_{DW} m^{-3}), whereas biofilm total protein (TP) values were dependent on nitrate loading rate (0.11→0.25 kg_{TP} m^{-3}). A very low content of total polysaccharides was also observed. The biofilm wet and dry densities were not strongly dependent on nitrate loading rate (1024→1063 $kg_{wet\ biofilm}$ m^{-3} and 20.2→25.1 $kg_{wet\ biofilm}$ m^{-3}).

Due to the characteristics of the carrier, the superficial liquid velocity needed to expand the bed in the inverse fluidized-bed reactor is lower than the one in the common fluidized-bed. It was observed that by increasing the nitrate loading rate, gas production and bed expansion increased. The gas bubbles moving upward intensify the turbulence around the carrier particles and seem to prevent them from agglomerating (which could easily happen due to the fast growth process of the heterotrophic microorganisms).

The nitrate loading rate could be further increased and the maximum denitrification capacity of the reactor is under investigation.

References

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