

Development and optimisation of VFA driven DEAMOX process for treatment of strong nitrogenous wastewater

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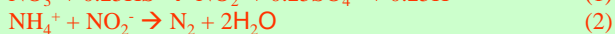
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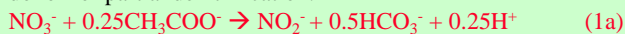
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Introduction

A new biological nitrogen removal process called DEAMOX for treatment of strong nitrogenous wastewater has been recently proposed (Kalyuzhnyi *et al.*, 2006). It combines the anammox reaction with autotrophic denitrifying conditions using sulphide as an electron donor for the production of nitrite from nitrate within an anaerobic biofilm:

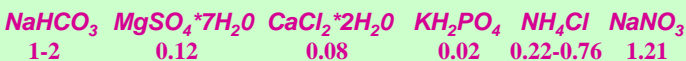


Since the standard application of this process is restricted to sulphur bearing wastewater, the objective of this poster was to perform a feasibility study of the DEAMOX process under replacement of sulphide by volatile fatty acids (VFA) as a more widespread electron donor for partial denitrification:



Materials and Method

The synthetic wastewater resembling reject water after sludge anaerobic digestion was based on the following mineral medium (g/l):



1.4 ml/l of standard micronutrient solution and the corresponding amounts of VFA (butyrate:propionate:acetate – 1:1:1 as COD) or sole acetate were added to this medium before being fed to the DEAMOX-reactor. The influent pH was 6.0-6.5. As a DEAMOX reactor, the UASB-type reactor (total working volume - 1.06 l) kept at 35 °C was used. It was seeded with 0.5l of the DEAMOX sludge having a substantial heterotrophic denitrifying activity from the previous study (Kalyuzhnyi *et al.*, 2006)

Results and Discussion

The required COD/N-NO₃ ratio for partial denitrification (reaction 1a) with taking into account the COD expenses for biomass growth (0.4 g biomass-COD/g COD, Henze *et al.*, (1997)) is 1.9. However, if denitrification of nitrite proceeds further according to the reaction:



the COD/N-NO₃ ratio (using the same biomass growth yield) increases to 4.76. Since the reaction 1ba is highly undesirable for VFA-driven DEAMOX process, the COD/N-NO₃ ratio was maintained close to the minimal required value (~ 2.3) during the start-up period. Then the steady state performance of this reactor was investigated under variation of some process parameters (Figs. 1-2).

It is seen (Fig. 1a) that the increase of nitrogen loading rate (NLR) from 211 till 1236 mg N/l/d almost did not influence the ammonia removal (variation 38-42%), however, led to a decrease of NO_x removal from 96 to 74%. As a result, the total N removal also decreased from 66 to 56%. The most significant deterioration of the process performance occurred under the shortest hydraulic retention time (HRT) of 0.31 days. The ratio of ammonia consumed vs nitrate consumed was pretty stable – around 0.5. The ratio of COD consumed/N-NO₃ consumed had a tendency to increase (from 2.65 till 2.98) with HRT decreasing and was significantly higher than the theoretical value for denitrification of nitrate to nitrite (1.9) witnessing about a substantial occurrence of reaction 1b. The effluent contained only traces of VFA. In order to investigate an influence of COD source on the process performance, we fed sole acetate to the DEAMOX reactor in the next experiment.

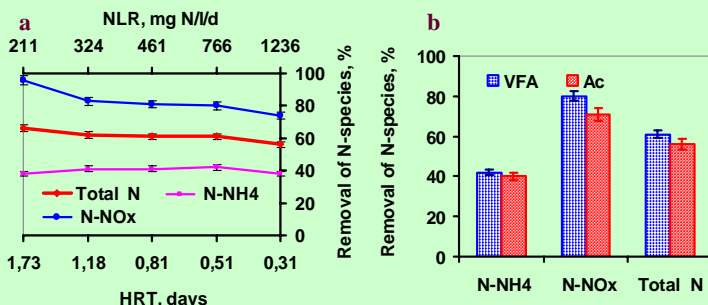


Fig. 1. Steady-state performance of the VFA-driven DEAMOX process under variation of: (a) NLR (VFA as COD source); (b) COD source (NLR ~ 750 mg N/l/d). Influent COD/N-NO₃ ratio ~ 2.25.

It is seen (Fig 1b) that acetate alone seems to be less eatable substrate for full denitrification compared to VFA mixture because the efficiency of nitrate removal dropped, meantime, the efficiency of ammonia removal was comparable. As a result, the overall efficiency of nitrogen removal slightly dropped in the case of acetate (Fig. 1b).

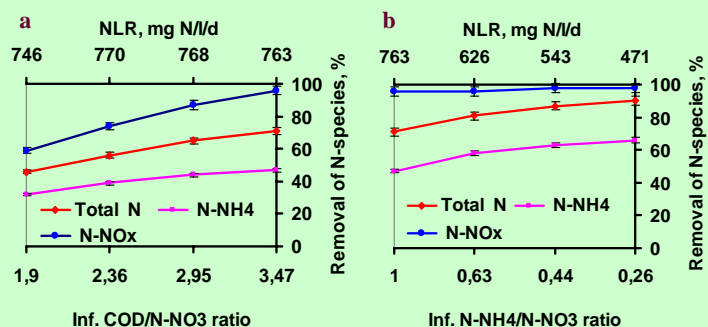


Fig. 2. Steady-state performance of the acetate-driven DEAMOX process under variation of: (a) influent COD/N-NO₃ (influent N-NH₄/N-NO₃ – 1); (b) influent N-NH₄/N-NO₃ (influent COD/N-NO₃ – 3.45).

Since acetate alone demonstrated a comparable efficiency as that of VFA mixture, the further experiments were conducted with this substrate. It is seen (Fig. 2a) that the increase of influent COD/N-NO₃ ratio from 1.90 till 3.47 led to a moderate increase of ammonia removal (from 32 to 47%) and substantial increase of NO_x removal (from 59 to 96%). As a result, the total N removal also increased from 46 to 71%. The most significant deterioration of the process performance occurred under the smallest influent COD/N-NO₃ ratio of 1.90 due to a shortage of COD donor for denitrification of nitrate even to nitrite. The ratio of ammonia consumed/nitrate consumed had a slight trend to decrease (from 0.54 to 0.49) whereas the ratio of COD consumed/N-NO₃ consumed had a slight tendency to increase (from 3.22 to 3.66) with increasing the influent COD/N-NO₃ ratio. Since it was impossible to avoid an occurrence of reaction 1b in this system, the influence of influent N-NH₄/N-NO₃ ratio was also studied (Fig. 2b). It is seen that the decrease of this ratio from 1 to 0.29 led to a substantial increase of ammonia removal (from 47 to 80%) resulting in the increase of total N removal from 71 to 95% (removal of NO_x species was almost complete).

Conclusions

Thus, the DEAMOX process can be realised under replacement of sulphide by VFA as an electron donor for production of nitrite. However, VFA seem to be less efficient (in terms of COD required) for this purpose.