Proceedings of the 2nd International Anammox Symposium (IANAS 2013). COEX, Seoul, Korea, June 11-12, 2013.

Enhanced deammonification of livestock wastewater using Brocadia caroliniensis and HPNS in single tank process

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Introduction:

Farmers that would like to implement biological nitrogen (N) removal from the effluent of anaerobic digesters (AD) – for example to comply with regional surplus nitrogen regulations or to take advantage of environmental nutrient crediting programs – are often limited by the low amount of carbon available for traditional denitrification, since the carbon is used for the production of biogas. A better approach would be to use biological deammonification. The deammonification process is a completely autotrophic nitrogen removal approach that combines partial nitritation and anammox and eliminates the carbon needs for denitrification. It also reduces the aeration needs of ammonia removal by about 60%. Thus, it could be a key approach for development of effective biological removal of ammonia (NH_4^+) from anaerobic digester effluents that are low in carbon and high in ammonia concentration. In this work we describe new findings that allowed rapid implementation of deammonification reaction in AD effluents using mixtures of bacterial cultures and a one-stage process (partial nitritation and anammox in a single tank).

Material and Methods:

We obtained rapid deammonification reaction by mixing in single, aerated reactors two bacterial cultures a high performance nitrifying sludge, HPNS, accession number NRRL B-50298, with anammox bacterial sludge, Brocadia caroliniensis, accession number NRRL B-50286. The reactors contained biofilm plastic carriers (30-40% v/v) that were fluidized by the aeration [3]. The single-tank reactors were tested with digested swine wastewater. The process water temperature was ambient 23±2^{o}C. The aeration rate applied varied from 300 to 850 mL/min as N loading rate increased from 0.8 to 1.4 kg N/m3-reactor/day in the 5-L reactor. The aeration rate in the 1-L reactor was 40-100 mL/min. During aeration, the DO was generally below 0.6 mg/L.

Results and Discussion:

High rates of ammonia removal were obtained in a single tank (1.03 kg N/m3-reactor/day) with ammonia removal efficiency of 100% and total N removal efficiency of 89%. The reactions obtained with swine wastewater were consistent with the theory of the deammonification process: $NH_4^+ + 0.87\ O_2 \rightarrow 0.45\ N_2 + 0.11\ NO_3^- + 1.18\ H^+$. Compared with traditional N removal, the deammonification process reduced 56-57% of the aeration. The nitrogen was removed in a single-tank, further reducing equipment costs. Therefore, deammonification is a key technology for development of more economical and energy efficient biological ammonia removal systems in the near future. Microbial reverse transcription analyses indicated that bacteria in the influent had little effect on the bacterial community that was active in the single-tank. Results showed physiologically high activity of ammonia oxidizing bacteria (AOB) and anammox bacteria in the reactor.

Conclusions:

We evaluated deammonification treatment using single, fluidized, aerobic reactor tank by mixing a high performance nitrifying sludge and anammox bacteria. Surprisingly, the two bacteria groups were able to associate quickly and effectively in the aerated single tank providing a streamlined ammonia removal process. Thus, the single tank configuration offers the potential to further reduce the cost of treatment of ammonia in livestock wastewaters containing high ammonia.

References

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Figure 1: Deammonification treatment using single-tank to perform partial nitritation and anammox in a fluidized continuous flow aerated reactor. A) 5-L reactor set-up, B) Mixing of HPNS with anammox, and C) Reactor detail with plastic carriers inside.

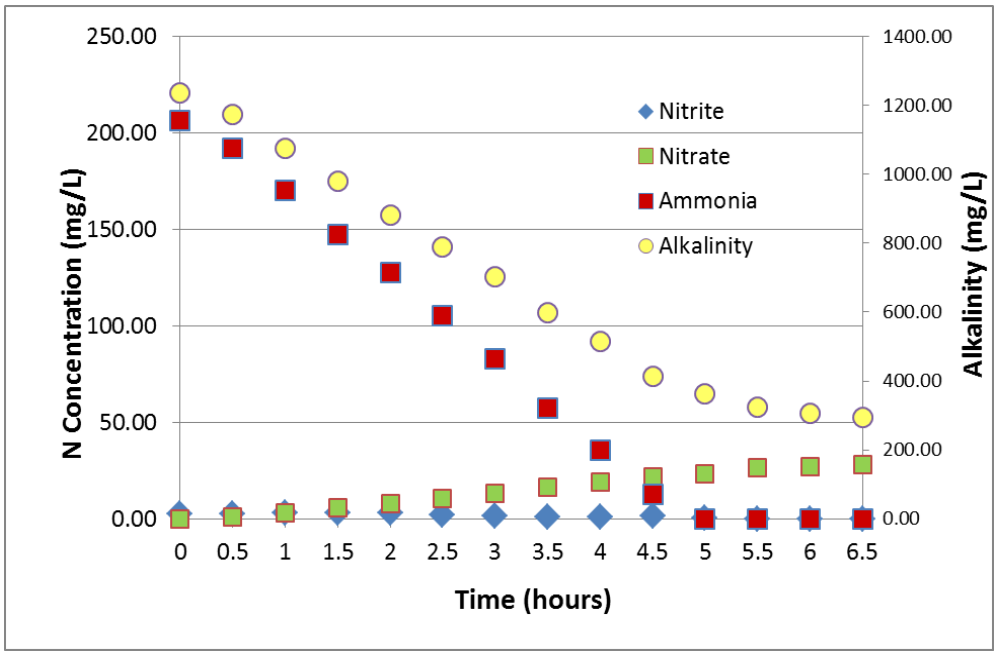

Figure 2: Deammonification treatment of digested swine wastewater in batch conditions.