Ph.D. Final Oral Defense

Eric T. Staunton

Integrated Biological Treatment of Swine Waste for Nitrogen Removal and Energy Recovery

Tuesday, 9 December 2014 | McGavran-Greenberg 1304 |2:00 P.M.

Nitrogen emissions associated with swine waste management have been identified as sources of several adverse public health and environmental effects, including: contamination of drinking water, respiratory diseases, production of ground level ozone, depleting stratospheric ozone, release of greenhouse gases, and acidification of soils and watersheds. These adverse effects make the technologically and economically feasible removal of nitrogen highly desirable. To understand the technological feasibility of nitrogen removal from swine waste, two biological systems were designed and operated: a traditional, pilot-scale, Modified Ludzack-Ettinger (MLE) process; and a lab-scale, single-reactor, nitritation/anaerobic ammonium oxidation (anammox) process.

The MLE process removed ~98% influent ammonium-N and ~83% influent total-N. Approximately 75% of the chemical oxygen demand (COD) was oxidized; the majority of COD was utilized as a source of electron equivalents for denitrification. The concentration of COD varied seasonally and full-scale N removal is expected to vary seasonally as well. There was only enough COD for complete denitrification in winter months. Alkalinity in the waste is insufficient to meet the demand associated with nitrification, although the extent of external alkalinity addition is expected to vary seasonally. Of the removed nitrogen, ~8% was released as nitrous oxide, primarily as a side-product of nitrification.

The single-reactor nitritation/anammox process removed up to 96% of influent ammonium-N and up to 90% influent total-N. Several observations indicated anammox as the primary N removal pathway though the relative contribution of denitrification is unknown. This system required at least 49% less oxygen than a conventional nitrogen removal system and required no external alkalinity which should minimize the cost associated with nitrogen removal. Of the removed N, 11% was converted to nitrous oxide.

The microbial community associated with nitritation/anammox was examined by quantitative PCR and bar-coded amplicon sequencing. The microbes known to perform anammox were found to comprise a small fraction of the total biomass. A significant shift in the dominant anammox bacteria was observed, from a seed culture dominated by Candidatus Brocadia to Candidatus Kuenenia dominating in the reactor biomass. An uncharacterized Planctomycete was identified as a dominant member of the community though it is unknown if this microbe performs anammox.

Committee:

Michael Aitken, Ph.D.
Glenn Walters, Ph.D.
Stephen C. Whalen, Ph.D.
Jill Stewart, Ph.D.
Marc Deshusses, Ph.D. (Duke University)
Ann Matthysse, Ph.D. (Biology)