Aerobic Granular Systems: the Treatment of Nitrogen Deficient Wastewater

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ABSTRACT

This Masters thesis demonstrated for the first time that it is possible to generate aerobic granules using a nitrogen deficient wastewater; and that such systems utilise nitrogen fixation for sustaining balanced growth. Furthermore, the performance of nitrogen fixing granular systems was shown to be comparable to conventional aerobic granular systems: they exhibited a high level of carbon removal and excellent biomass settleability.

Using a specially developed image characterisation technique, granule parameters were analysed to investigate the formation of nitrogen-fixing granules and subsequently to compare the effects of turbulence on these nitrogen fixing granules; a nitrogen supplemented system was utilised as a control. Sequencing batch reactors (SBRs) with a short (1 minute) settling phase were used for the experiments. The length of the settle phase was based on the results of a preliminary study which showed that granules grown with a 1-minute settling time are significantly larger (and more irregular) than granules grown in reactors with longer settling times.

Granules were generated in both the nitrogen deficient system and the control. The difference between the granules grown under nitrogen-deficient and nitrogen-rich conditions was evident through image analysis revealing differences in granule size and structure. Those granules grown without nitrogen supplementation were denser and larger than those grown with supplementation. It is proposed that the difference in morphology is due to the function of nitrogen-fixing bacteria in the nitrogen deficient system. These bacteria utilise the nitrogenase enzyme and so prefer an environment with low oxygen concentration. It is proposed that nitrogen fixers proliferate inside the granule due to the oxygen concentration gradients created through diffusion limitations.

The effect of turbulence levels on the formation of nitrogen-fixing granules was pronounced. The comparison of high and moderate aeration/turbulence reactors found that granules grown under the less turbulent regimes were more filamentous, irregular

and had slower settling velocities than those grown under greater turbulence. Without a minimum turbulence threshold granules were not generated and a biofilm became the dominant microbiological form within the reactor.

Based on the results of this work, it is proposed that an SBR with a short settling phase and high turbulence could be employed to develop nitrogen-fixing granules for the treatment of nitrogen deficient wastewater. The primary benefits for such a system are good sludge settleability and removal of the need to supplement nitrogen for growth.

Notice of Publications

Some information and research from this thesis has been published or submitted.

1. Tan L.B.M., Gapes D.J., Pratt S. (2004) Image Analysis of Aerobic Granulation in Biological Wastewater Treatment Systems. Proceedings from the 2004 APCSEET Conference. Wellington.

   - information from Chapter 4 and Chapter 5

2. Pratt S., Tan M., Gapes D., Shilton S. (2006) Development and examination of a granular nitrogen-fixing wastewater treatment system. Journal of Process Biochemistry. *Submitted.*

   - information from Chapter 6

3. Tan L.B.M., Gapes D.J., Pratt S. (2005) Growing Granules to Treat Nitrogen Deficient Waste. Poster in the MacDiarmid Young Scientist of the Year Awards 2005.

   - information from Chapter 4 and Chapter 5