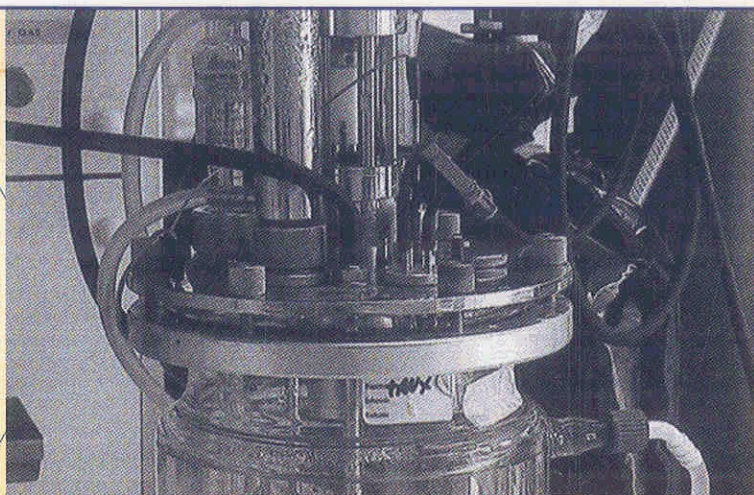


The Combined Sharon/Anammox Process

A sustainable method for N-removal from sludge water



L.G.J.M. van Dongen

M.S.M. Jetten

M.C.M. van Loosdrecht

Contents

<i>Preface</i>	<i>vii</i>
Overview	1
1 Introduction and background	3
2 Process description	7
2.1 The Sharon process	7
2.1.1 Temperature	8
2.1.2 pH	9
2.2 The Anammox process	9
2.2.1 Reactor performance (design/construction)	11
2.3 Combined Sharon/Anammox	11
3 Process performance	13
3.1 The Sharon process	13
3.1.1 Experimental set-up	13
3.1.2 Process conditions in the Sharon reactor	15
3.1.3 Analysis and experiments	15
3.2 The Anammox process	17
3.2.1 Experimental set-up	17
3.2.2 Process conditions	19
3.2.3 Analysis and experiments	20
3.3 Combined Sharon/Anammox process	22
3.3.1 Process conditions	22
3.3.2 Analysis	22

4	Results and discussion	23
4.1	The Sharon process	23
4.1.1	Conversions in the Sharon process	23
4.1.2	pH and conversion rates	25
4.1.3	Maximum conversion rates and affinity constants	26
4.1.4	<i>Bicarbonate content</i>	28
4.1.5	Sludge characterisation	28
4.1.6	Influence of anaerobic conditions on ammonium oxidisers	29
4.1.7	Protozoa	29
4.2	Start-up of the Anammox reactors	32
4.2.1	Enrichment of Anammox biomass with synthetic wastewater	33
4.2.2	The Anammox reactor during stable operation	34
4.3	Combined Sharon/Anammox	34
4.3.1	Enrichment of Anammox biomass with effluent from the Sharon reactor	34
4.3.2	Conversion(s) in a combined Sharon/Anammox system	35
4.4	Characteristics of the Anammox system	36
4.4.1	Maximal activity	36
4.4.2	Tests with hydroxylamine	37
4.4.3	Sludge characterisation using FISH analysis	38
4.4.4	Nitrifiers in Anammox	38
4.5	Evaluation of the experimental programme	40
5	Process design and economic feasibility	43
5.1	General performance	43
5.1.1	Start-up	44
5.1.2	General process control and warning system	44
5.1.3	Process disturbances	45
5.2	Choice of reactor	46
5.3	Design	47
5.3.1	Calculations	48
5.4	Economic evaluation	49
5.4.1	<i>Assumptions</i>	49
5.4.2	Estimate of costs	49
6	Conclusions and recommendations	51
	Bibliography	53
	Appendix A: Growth tests with protozoa	55
	Appendix B: Assumptions for cost estimate	59
	Index	63