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COD Removal and Nitrification of Piggery Wastewater in a Sequencing Batch Reactor

A thesis submitted in partial fulfilment
of the requirements for the degree
of

MASTER OF TECHNOLOGY
in
ENVIRONMENTAL ENGINEERING
by
WING NGA WONG

Institute of Technology and Engineering
Massey University

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Errata Sheet

Pg		
11	Ln 2	New Zealand (1995) should be New Zealand Ministry of Health (1995)
12	Ln 6	Corrected word from "micro organism" to "microorganisms"
14	Ln 4	Corrected reference from (Blouin *et al*, 1989) to (Blouin *et al*., 1990)
14	Table 2.1	Corrected references to "Ten Have *et al.* (1994)" ; "Andreottola *et al.* (1997)"
15	Sect. 2.3	Lower case for faecal coliforms; enterococci replaces *Streptococci*
15	Ln 3	Corrected reference to Blouin *et al.* (1990)
15	Lns 5,6,7	Concentration of *Nitrosobacteria* was 990 MPN/ 100 ml, *Nitrobacteria* concentration was $2.8 * 10^5$ MPN/ 100 ml. Inoculations of bacteria were 10^6 - 10^9 MPN/ 100ml
16	Para.4, ln 2	Replace "chemotrophs" with "chemoautotrophs"
17	Sect. 2.7	Equations rewritten as: $6NO_3^- + 2CH_3OH \rightarrow 6NO_2^- + 2CO_2 + 4H_20$ (2.3) $6NO_2^- + 3CH_3OH \rightarrow 3N_2 + 3CO_2 + 3H_20 + 6OH^-$ (2.4) $6NO_3^- + 5CH_3OH \rightarrow 3N_2 + 5CO_2 + 7H_20 + 6OH^-$ (2.5)
23	Para 2, ln 4	Corrected underlined word ...*Nitrobacter* growth rates using <u>nitrite</u> as the limiting substrate.
28	Ln 3	Reference: Bernardes, R.S. and Klapwijk, A. (1996). Biological Nutrient Removal in a Sequencing Batch Reactor Treating Domestic Wastewater. <u>**Water Science and Technology**.33</u> (3) pp. 29-38
29	Ln 7	Lower case for "faecal coliforms" ; replace "Faecal *Streptococci*" with "enterococci"
30	Table 2.5	Corrected reference to Wong *et al.* (1990)
32	Sect.3.2.4 ln 1	State reference as APHA Standard Methods (1995)
33	Sect.3.2.5.2 ln 1	State reference as APHA Standard Methods (1995)
42	Lns 2 & 17	Replace "whom" with "who"
47	Fig 4.3	Legend for first 9 weeks "SBR cycle time = 24 hours"
54	Last line	Replace reference to Fig 4.8 with Fig 4.7
61	Para.2, ln 4	Add underlined word: " of <u>the</u> successive"
61	Para. 3	1st sentence rewritten: As ammonia oxidation rates increased from the day 160 to 236 batch test, thus in the day 256 batch test, it was predicted that 6 hours for the initial aerobic period was sufficient in removing of most of the ammonia.
61	Para.3, ln 7	Replace the word "were" with "was"
61	Para 4, ln 4	Replace the word "oppose" with "opposed"
64	Table 4.8	Correct μ value to 2 decimal place as "0.1524" becomes "0.15"
65	Sect. 4.12 ln 1	Express μ_{max} as 0.29 hr^{-1}
66	Fig 4.16	x-axis is S (mg/l), y-axis is S/μ (mg.h/l)
69	1st and 2nd sentence	combined 1st and 2nd sentence. ...waste was in the day 256 test, however in day 276...
69	Para 2, ln 3	Correct sentence to "Thus indicating that factors other than reaction rate affected the overall removal of nitrate."
81	Ln 1	Correct reference to New Zealand Ministry of Health (1995)

Abstract

Piggery wastewaters are particularly problematic when released untreated into the environment. They contain high levels of chemical oxygen demand (COD) and also nutrients such as nitrogen and phosphorus which can cause eutrophication in surface waters.

The sequencing batch reactor is a form of biological treatment in a completely mixed reactor with aerobic and anoxic periods to facilitate nutrient removal. In this study nitrogen removal of piggery wastewater in a SBR by nitrification and denitrification was investigated.

Screened raw piggery effluent was used in this study. Average non filtered feed contained a chemical oxygen demand of 12,679 mg /l. The average of the non filtered feed TKN was 1103 mg/l with its largest component being ammonia having an average concentration of 681 mg/l (non filtered feed).

Initial experiments with solids retention time (SRT) of 15 days and the hydraulic retention time (HRT) was 5 and 3.3 days for 9 and 4 weeks respectively during Stage 1. No significant nitrification activity was observed during this period. The reactor cycle time was then increased to 2 days which effectively increased the SRT to 30 days and HRT to 6.7 days (Stage 2). The new environment allowed the nitrifying population to develop and nitrification was observed with the formation of nitrite and nitrate.

The heterotrophic kinetic constants determined the yield coefficient as 0.49. The maximum specific growth rate (μ_{max}) was 6.8 day^{-1} and half saturation constant (K_s) was 293.6 mg/l.

The COD removal of the feed in the SBR started from around 70% in weeks 6-10 during Stage 1 and reached 92.7% in week 29. Ammonia removal was not significant in the first 17 weeks due to no significant nitrification activity during that time. After initiating a 2 day reactor cycle, ammonia removal rates increased to over 90%.

Batch tests indicated that most of the ammonia needed to be remove in the first aerobic period. This allows nitrite and nitrate concentrations to build up and be removed by the subsequent anoxic period. This was when there was enough readily degradable COD as not to inhibit denitrification.

The reactor cycle time which achieved full nitrification and the highest nitrate removal by denitrification was observed in the batch test on day 256. The first 6 hour aerobic period removed 81.1% of the ammonia. Subsequent anoxic periods reduced the nitrate concentration in the effluent to 11.0 mg N/l.

The nitrification rates increased in the reactor over time as the nitrifying population acclimatised to the piggery effluent. In fact the highest nitrate formation and ammonia oxidation rate was 15.5 mg N/l. h and 24.6 mg N/l.h measured during the last test on day 270. Nitrite formation rates peaked at 11.5 mg N/l.h. The SBR biomass population was able to remove nitrate efficiently as batch tests showed that denitrification rates could reach 22.1 mg N/l.h.

The relationship between effluent nitrate levels and COD: ammonia concentration ratio was assessed in order the determine the importance of these chemical characteristics important in controlling the nitrification and denitrification activity in the SBR. Results showed that as the COD: ammonia concentration ratio increases, the effluent nitrate levels decreases.

The study found that the SBR was suitable in removing COD and Nitrogen from piggery wastewater.

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