DYNAMIC MODELING AND SIMULATION OF THE IMPACT OF MICRO-AERATION ON ANAEROBIC TREATMENT OF SULFATE-RICH WASTEWATER

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DECLARATION

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

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Name of Supervisor: **UOM Verified Signature** asiri

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DEDICATION

Dedicated with gratitude to my loving **MOTHER** for being the greatest plier of my life.

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ABSTRACT

This study investigates the application of micro-aeration to remove dissolved sulfide produced during the anaerobic treatment of wastewater containing sulfate. A completely mixed batch reactor was used to develop a dynamic model of batch anaerobic digestion with micro-aeration of the liquid phase using BioWin (version 6.2) software to simulate the performance of sulfate reduction and sulfide oxidation in a single reactor unit. When calibrating the micro-aerated model, maximum specific growth rate for sulfur-reducing acetotrophic bacteria was set to 0.38 d^{-1}, switching function of sulfur reducing pathway DO half saturation concentration was set to 0.0001 mgO_2/L and air was introduced to the system at two stages; for 12 hours at a rate of 0.018 m^3/hr and another 12 hours at a rate of 0.015 m^3/hr. When comparing the calibrated micro-aerated model and the strictly anaerobic model, rate of sulfate reduction reduced with micro-aeration, but complete removal could be expected. Although methane production improved over the first half of the time period in calibrated micro-aerated model, a negative impact of the presence of oxygen on methanogens could evident when the oxygen presents in the system beyond 13 hours. The calibrated micro-aerated model showed a significant decrease in dissolved sulfides when compared to the anaerobic model. Moreover, an average of 80% H_2S removal could be achieved with micro-aeration. It indicates the possibility of adapting micro-aeration in liquid phase of anaerobic reactors to reduce formation of gaseous H_2S by oxidizing dissolved sulfides to elemental sulfur, alongside the simultaneous removal of sulfate.

Keywords: Micro-aeration, Sulfate reduction, Anaerobic, BioWin, Dynamic simulation

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LIST OF ABBREVIATIONS

Abbreviation	Description
AD	Anaerobic digestion
ADM1	Anaerobic Digestion Model No. 1
COD	Chemical oxygen demand
DO	Dissolved oxygen
IWA	International Water Association
LCFA	Long-Chain Fatty Acids
MABR	Membrane aerated biofilm reactor
MPO	Methane-producing organisms
ORP	Oxidation-reduction potential
SOB	Sulfur-oxidizing bacteria
SRB	Sulfate-reducing bacteria
UASB	Up-flow anaerobic sludge blanket
VFA	Volatile fatty acids
Fbs	Readily biodegradable (including Acetate) (gCOD/ g of total COD)
Fac	Acetate (gCOD/ g of readily biodegradable COD)
Fus	Un-biodegradable soluble (gCOD/g of total COD)
Fup	Un-biodegradable particulate (gCOD/ g of total COD)
Fna	Ammonia (gNH_3-N/ gTKN)
Fnus	Soluble un-biodegradable TKN (gN/gTKN)
Fpo4	Phosphate (gPO_4-P/ gTP)
Fsr	Reduced sulfur [H_2S] (gS/ gS)
µ_max	Sulfur-reducing acetotrophic maximum specific growth rate (d^{-1})
K_m_ac	Acetic acid half saturation constant for sulfur-reducing acetotrophic bacteria (mgCOD/L)

K_m_s	Sulfate half saturation constant for sulfur-reducing acetotrophic bacteria (mgS/L)

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