Investigation of the closed loop processing systems developed for microalgal biofuels.

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This thesis is submitted for the degree of Doctoral of Philosophy

In

The School of Chemical Engineering

At

The University of Adelaide

February 2015.

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Declaration for a thesis that contains publications

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Thesis by publication

This doctoral thesis is submitted as a portfolio of peer-reviewed publication according to the "*PhD Rules & Specification for Thesis*" of the University of Adelaide. The journals in which these papers were published or accepted are closely related to the research field of this work. The citation information is listed and the journals ranked in the order of impact factor in reference to their scientific significance.

	Journal Title	Impact Factor	Citations
1	Bioresource Technology	5.039	5
2	Bioresource Technology	5.039	2
3	Bioresource Technology	5.039	-
4	Bioresource Technology	5.039	-
5	Bioprocess and Biosystems Engineering	1.823	-

The thesis is composed of the following papers:

1. Mason Erkelens, Andrew S. Ball, David M. Lewis (2014), *The influences of the recycle process on the bacterial community in a pilot scale microalgae raceway pond.*, Journal of Bioresource Technology.
2. Mason Erkelens, Andrew S. Ball, Andrew Ward, David M. Lewis (2014), *Microalgae digestate effluent as a growth media for Tetraselmis sp. in the production of biofuels*, Journal of Bioresource Technology.
3. Mason Erkelens, Andrew S. Ball, Andrew Ward, David M. Lewis (2014), *The influence of protozoa with a filtered and non-filtered seawater culture of Tetraselmis sp.*, Journal of Bioresource Technology.
4. Mason Erkelens, Andrew S. Ball, David M. Lewis (2015), *The application of activated carbon for the treatment and reuse of the aqueous phase derived from the hydrothermal liquefaction of a halophytic Tetraselmis sp.*, Journal of Bioresource Technology,
5. Mason. Erkelens, Xiaoyu Ma, Wynand Van Den Berg, Andrew. S. Ball, Steven. Amos, David. M. Lewis (2015), *Reducing microalgae biofuels water footprint by recycling water and its effects on the bacteria and microalgal communities*, Bioprocess and Biosystems Engineering, Submitted

The following additional outcomes resulted from PhD work associated with the research carried out:

Sanaz Orandi*, Mason Erkelens*, Andrew S Ball, Amini, David M Lewis (2014), *An Investigation of the bacterial community dynamics of a microbial biofilm, exploited for the biotreatment of acid mine drainage*, joint lead author, submitted to the Journal of Extremophiles.

Mason Erkelens, Peter Forward, Martin Lambert, *The bacterial community within a 28km bore system with iron bacteria."* Submitted.

Mason Erkelens*, Peter Forward, Martin Lambert, *Characterisation of Bacterial Iron Nanowires from biofilm: towards large scale production of nanomaterias from the environmental waste*, Poster presentation, ICONN conference, Adelaide, 2014.

Mason Erkelens, Krishna Kant, Peter Forward, Martin Lambert, *Large scale production of iron oxide nanowires*, Oral presentation, RACI conference, Adelaide, 2014.

Mason Erkelens, Andy Ball, David Lewis, *The influence of the recycle process on the bacterial community in a pilot scale microalgae raceway pond*, Poster presentation, ISAP conference, Sydney, 2014.

Mason Erkelens, Mohamad Taha, Akin Adututu, Laureta, John Aniborg, Andy Ball, *Sustainable remediation – The application of bioremediated soil for the use in the degradation of TNT chips,* Journal of Environmental Management, Impact factor 3.55.

Mason Erkelens, Andy Ball, David Lewis, *The influence of microalgae digestate on microalgae biofuel production*, Poster presentation, EMBL symposium, 2012.

Mason Erkelens, Andy Ball, *Sustainable remediation – The application of bioremediated soil for the use in the degradation of TNT chips,* Oral presentation, Australian Energetics Symposium, 2012.

Awards

2012 Awarded Travel research scholarship

2012 Joint Research Engineer scholarship

2012 EMBL PhD travel symposium scholarship

2012 Awarded EMBL PhD research travel scholarship

If I want to summarise my thesis in one sentence, I would say:

"*Looks like pea soup, but it's actually the future of crude oil production.*"

Mason Erkelens

December 2014.

Acknowledgements

I would like to thank everyone who has helped me get to where I am today.

Firstly I would like to thank my family for supporting me throughout my whole educational journey, they have supported me and pushed me to exceed.

I would like to thank Kerri Wester my partner for being there with me from my honours, she has been great support during my studies.

I would like to especially thank Prof Andy Ball for accepting me into honours, and then taking me on for a PhD. Without Prof Andy Ball I would not be here to this day, he took me on as a 3rd year student, and then accepted me for honours. The training in the Ball Lab was the best I have ever received, from that training I have been able to be competitive within the scientific community. Without him I would have not be where I am today and I thank him for that.

I would also like to thank A/Prof David Lewis, he accepted to take me on as a PhD student and as my Primary supervisor. He has been a great teacher and also a great mentor! A/Prof David Lewis has made it possible for me to finish the PhD.

I would also like to thank Prof Peter Ashman for accepting me as his PhD student, he has been very good to have a supervisor.

I would also like to thank Prof Martin Lambert for support me through this PhD by continuous encouragement, this encouragement has helped me finish my thesis for submission.

I would like to thank all my co-authors in all my papers, Steven Amos, Andrew Ward, Sanaz Orandi, Ivy Ma, Wynand van den Berd, Daniel Lane, Anne Philcox. I will remember all of you and hope that someday we will cross paths in the same research group again.

I would also like to thank Prof Alan Cooper and his research group for accepting me to join their weekly meetings, it has opened my eyes to the future of the metagenomics field.

Abstract

The algal biofuels industry is under development and being investigated at large scale all around the world. To improve the viability of algal biofuels the ability to use closed loop systems that recycle waste and water thereby decreasing the overall waste produced while increasing profitability is being investigated. The aim of this work was to investigate closed loop systems associated with the algal biofuel production, focusing on its effects on the production of algal biomass and lipid and on the natural microbial community. The key areas of algal production that have been the focus of the research are the introduction of water, and the recycling of water and the recycling of waste produced during the biomass to biofuel stage of the microalgal biofuel process. Water is a key part of microalgal biofuel production; the source of water can contain many different microorganisms that can affect microalgal growth.

Recycling waste streams back into the culture as a nutrient stream is an effective way to reduce the cost of production. Within this thesis I investigated two waste streams as a potential nutrient stream, microalgae digestate and the hydrothermal liquefaction aqueous phase (Chapter 3 and 4). I observed that high concentrations of either of the waste streams resulted in reduced growth in comparison to F/2 media. Negative growth was associated with high concentrations of ammonia, and the effect of the use of waste streams was species dependent.

There is currently little known about the changes in the bacterial and algal communities during the harvesting/recycle process. Within chapter 5 and 7 I investigated the bacterial and algal diversity present during these processes. It was observed that while the electroflocculation stage had little impact on the bacterial community, the centrifuge stage was shown to have a much higher impact on the bacterial community. The recycling process also increased the dominance of *Tetraselmis MUR233* over various recycle stages. A benefit of recycling is the

prevention of undesired microorganisms entering into the culture. One microorganisms that is of interest is Protozoa, due to the potential damages to microalgae biomass production. Within chapter 6 I observed the effects of protozoa within the culture; it was observed that was no significant difference between the final total lipid or final total dry weight produced in the presence and absence of protozoa. This study shows the ability of *Tetraselmis MUR233* to outgrow any potential damage caused by the presence of the protozoa.

Developing further understanding of these processes can help improve potential outcomes when these processes are undertaken.

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