UTS UNIVERSITY OF TECHNOLOGY SYDNEY

Application of microalgae and wastewater as plant nutrients and stimulants in hydroponic technology

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Thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

under the supervision of Professor John Zhou
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Certificate of original authorship

I, Swaminathan Palanisami declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Civil and Environmental Engineering, Faculty of Engineering and Information and Technology at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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Thesis abstract

Nitrous oxide is 300 times stronger than carbon dioxide in causing climate change, and 80% of global nitrous oxide is from nitrogen fertilisers used in soil-based agriculture. Finding ways to minimise the carbon footprint related to the production of nitrogen-based agricultural fertiliser, and reusing waste nutrients from wastewater, will benefit parallelly in saving the energy expenses of wastewater treatment and in producing fertilisers. This research proposes utilising high concentration wastewater, such as desalination brine, blended with secondary treated domestic wastewater in the optimal proportion to produce microalgae growth media. Cultivating nitrogen-fixing microalgae in blended wastewater yields a dual solution for wastewater nutrient recovery and obtaining biologically fixed nitrogen. The nitrogen-fixing microalgae remove (exhaust) all the nitrogen in wastewater and, for its further growth, fix (produce) nitrogen. The nitrogen produced by the microalgae is a usable form of plant nutrient. Microalgae are known to produce plant hormones; the acid-digested algal biomass (extract) can be used as a source of nutrients and plant stimulants to grow plants in hydroponics. Growing plants in hydroponics minimise nitrogen nutrient loss (as in soil-based agriculture) and nitrous oxide evolution. This study used non-hazardous sources of wastewaters to demonstrate the possibility of producing microalgae biomass using blends of high and low-concentration wastewaters and assessed its nutrient recovery rates. Applied algal biomass extract as a source of nitrogen and whole nutrients to grow plants in hydroponics and added effort to profile the plant hormones in the microalgal biomass.

The aims of this research focused on (i) using different wastewater nutrient concentrations as a source to attain an optimal microalgal growth media for biomass production and nutrient recovery from wastewater; (ii) comparing the efficacy of microalgal biomass extract-based hydroponic nutrients with other commercial hydroponic nutrients. Consequently, the objectives are (1) to develop a wastewater blending method for algal cultivation and nutrient recovery, (2) to examine the feasibility of producing hydroponic nutrients and stimulants from algal biomass, (3) to compare the growth efficiency of plant in algal extracts nutrients and other available hydroponic-nutrients. The comparative study of algal biomass extract-based hydroponic nutrients with other commercial products showed clear evidence

that the microalgal biomass-based hydroponic nutrients have commercialisation potentials. Further product improvement by using different algal species can yield high and robust nutrients and stimulants.