HYDROPONICS SYSTEM FOR WASTEWATER TREATMENT AND REUSE IN HORTICULTURE

By

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BEnvSc

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DECLARATION

I declare that this thesis is my own account of my research and contains as its main content work, which has not previously been submitted for a degree at any tertiary education institution.

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LIST OF PULICATIONS

Published papers

1. Oyama, N., Nair, J. and G. E. Ho (2005). Recycling of Treated Domestic Effluent from an On-site Wastewater Treatment System for Hydroponics. *Water Science and Technology* **51**(10): 221-220.
2. Oyama, N., Nair, J. and Ho, G. E. (2008). Utilising an integrated wastewater hydroponics system for small scale use. *Water and Environmental Management series*. 13-23.
3. Nair, J., Levitan, J. and Oyama, N. (2008). Zinc and copper uptake by silver beet grown in secondary treated effluent. *Bioresource Technology.* **99**: 2537-2543.

Papers presented at conferences

4. Oyama, N., Nair, J. and Ho, G. E. (2004). Wastewater Hydroponics for Horticulture. *IWA World Water Congress and Exhibition*. Marakech, Morroco, September 19-24 2004.
5. Oyama, N., Nair, J., Mathew, K. and G. E. Ho. (2005). Wastewater Hydroponics for Urban Food Production. *1st IWA-ASPIRE (Asia Pacific Regional Group) Conference & Exhibition.* Singapore, July 10-15 2005.
6. Oyama, N., Nair, J. and Ho, G. E. (2008). Comparison Of Pathogen Die-Off Patterns Of Tomatoes Grown In Two Hydroponics Systems. *1st International Conference on Technologies & Strategic Management of Sustainable Biosystems.* Fremantle, 6-9 July 2008.

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ABSTRACT

As human population increases, the need for water increases in domestic, agricultural, industrial and urban sectors. Wastewater reuse after treatment is gaining acceptance world wide, as availability of fresh water sources decreases. However, it is also important to point out social and cultural differences that still exist in different pars of the world including those where reuse of wastewater for food production or any domestic use is not yet acceptable. The major concerns with effluent reuse are primarily its impact on human health and environmental risk. As a result, effluent reuse should be undertaken with caution after careful consideration of the potential impacts and risks.

This thesis examined the potential to use the hydroponics nutrient film technique to grow commercially important crops using secondary-treated domestic wastewater. The crops chosen were a fruit crop (*Lycopersicon esculantum* - tomato), a leafy crop (*Beta vulgaris ssp. cicla* - silver beet) and a flower crop (*Dianthus caryophyllus* - carnation). Secondary-treated domestic wastewater was chosen because of the reduced risk of pathogen and heavy metal contamination in the crops and due to the guideline requirements for use of treated effluent for food crops. The possibility of using the effluent after the hydroponics treatment for further irrigation was also studied.

The ability of secondary-treated effluent to supply adequate nutrients to the crops was assessed relative to a commercially available hydroponics solution (Chapter 3). The amount of time the solution was left in the system (nutrient solution retention time) was dependant on the plant uptake of the solution. The results obtained showed that the nutrients in secondary treated effluent was adequate for the carnations, but not for

the food crops. The food crops from both treatments were compared to the produce purchased from a supermarket. The food crops showed signs of nutrient deficiency, particularly nitrogen.

Based on the findings of the first experiment, the nutrient solution retention time was amended to 14 days. The carnations were not tested with the shorter nutrient solution retention time (NSRT) because they performed well in the previous trial with the longer nutrient solution retention time. The edible food crops performed better and did not show signs of nutrient deficiency when the nutrient solution retention time was reduced to 14 days.

Further statistical analysis was conducted with the data from Chapters 3 and 4. Nutrient and water balances were calculated and the possible reason that the plants grown in the 14-day nutrient solution retention time took up more water, was a result of increased nutrients and better growth. A simple model was constructed to calculate height of the plants using multiple regression. The model was validated against the data collected from this study.

The experiment conducted in Chapter 6 determined the nutritional quality of the food crops. The harvests from the wastewater and commercially available hydroponics solution were compared to produce purchased from a supermarket and tested for total caroteniods, total soluble solids and ascorbic acid concentrations. The nutritional quality of the wastewater grown produce was comparable to those grown in the hydroponic solution and those purchased.

The risk of pathogen contamination to food crops and the die-off of pathogens in the hydroponic channels were studied in Chapter 7. This was tested by spiking the commercial hydroponic medium with *Escherichia coli* and *Salmonella typhimurium* and monitoring bacterial pathogen die-off in the secondary treated domestic wastewater. The pathogen quality of the crop was tested in all treatments as well as on organically grown produce found at a local supermarket. The results of this experiment did not show any contamination on the surface of the food crops or within the food crops.

This study demonstrated that growing tomatoes, silver beet and carnations using secondary-treated domestic wastewater was successful when the nutrient solution retention time was adjusted to the optimum level. In arid, developing and remote communities, this system is ideal as it conserves and reuses water for commercially important crops without compromising the health of the environment or of human beings. It can also be implemented in urban areas, as the system can be scaled according to the availability of space. In addition to this, the effluent after going through this system can be used for open irrigation as it meets the World Health Organisation guidelines.

However, a number of additional concerns need further investigation. They include the transmission risk of other types of pathogen, which depends on the source of wastewater, and the effects of hormones and antibiotics on food crops and their effect on human health.

ABBREVIATIONS

BOD	biological oxygen demand
CM	control medium (commercial hydroponics medium)
CMS	control medium spiked (commercial hydroponics medium spiked)
DO	dissolved oxygen
EC	electrical conductivity
ETC	Environmental Technology Centre
MAD	Maurice Alan Derrick
NATA	National Association of Testing Authorities
NFT	nutrient film technique
NH_4^+-N	ammonium-nitrogen
NO_3^--N	nitrate-nitrogen
NSRT	nutrient solution retention time
O	organically grown produce
PO_4^{3-}-P	phosphate-phosphorus
se	standard error
TKN	total kheldjal nitrogen
TN	total nitrogen
TP	total phosphorus
TSS	total soluble solids
WC	water culture
WHO	World Health Organisation
WW	secondary-treated domestic wastewater

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