FANTASTIC METALS & WHERE TO PHYT THEM

Assessing the Potential of Metal Accumulation in Edible Garden Plants

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Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

Under the supervision of Megan L. Murray & Brad R. Murray

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DECLARATION

CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Annie McDonald, declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy in the School of Life Science, Faculty of Science at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference 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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ABSTRACT

Land contamination is a major threat to global food security. Heavy metals are ubiquitous contaminants contributing to agricultural land degradation across the globe. Their potential to cause serious harm to ecosystems and human health has led to the development of innovative remediation technologies. Harnessing the natural uptake ability of plants, phytoremediation offers an environmentally friendly, and cost-efficient method of remediating heavy metals from soils. Among known phytoremediators, many are plants with edible tissues, which can be deployed on degraded sites to promote decontamination.

However, plants that accumulate high quantities of heavy metals into their edible tissues are a risk to food safety. With urban gardens in Sydney and Melbourne exceeding Australia's Health Investigation Guideline level for heavy metals in residential soils, this thesis investigates the potential of edible plants in remediating legacy soil contamination in Australian environments and evaluates the associated risks of these species to food safety.

A database analysis of edible phytoremediator plants from the literature identified a research gap of edible species tested under Australian environmental conditions. This study was followed by a germination experiment investigating single and multi-metal contaminant effects on the germination of eight commercially important crop species. Carrots were the only species able to germinate under complex multi-metal conditions inferring a greater risk to food safety if they continue to grow and accumulate metals *in situ*. In a controlled glasshouse experiment, mature root vegetable plants (i.e., carrots and radishes) posed the greatest risk to food safety, while common beans were found to accumulate appreciable concentrations of lead into brown leaf tissues compared to green leaves. These results

present a possible avenue for the application of common beans as phytoindicators in lead-contaminated environments. Leafy herbs presented greater risk in a real-world investigation of homegrown produce from residences in North Sydney, NSW. In addition, a landmark field garden trailed on the heritage-listed White Bay Power Station, NSW, showed potential for phytoremediation using edible plants as a non-invasive, long-term strategy for contaminated industrial sites.

The work presented in this thesis advances knowledge of the potential for edible plant phytoremediators to be used in Australian contexts with consideration of the associated risks to food safety. This research identifies crop species that pose lower or greater health risks based on edible tissue accumulation patterns. These findings inform species selection for the mitigation of risks to urban gardeners as well as providing candidates for future applications of phytoremediation in Australia.

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Wait, who said never meet your heroes? I didn't just meet mine, I had the incredible fortune to be taken under her wing as her student. Megan's passion for science and teaching is infectious and I'm awed by her generosity, optimism, and spunk. Unlike other celebrities, I've got your autograph (on all the forms you've had to sign). Seriously though, you are an incredible supervisor. I am forever grateful to you for your mentorship, friendship and support of this work which went above and beyond. It has opened doors and made this achievement possible. I have learned so much from you over the years, both professionally and personally. I'm so stoked to be privy to your wisdom. Thank you from the bottom of my heart for taking me on, guiding me, and helping me grow as a scientist and a human.

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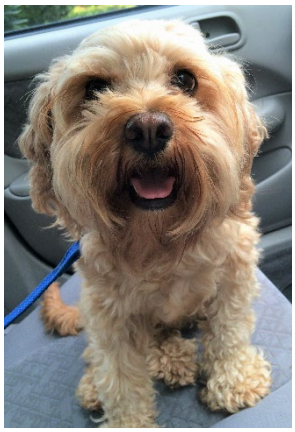
3 borks for my best companion and confidant, Copper. Despite being a dog, Cop is tertiary qualified by proxy after supporting her human not just through high school, but a Bachelors degree and now a PhD. Most insistent on sitting within a 5m radius, under my desk, or first class (my lap), Cop has learned that Copper is essential to human health. She knows we’re not just talking about the heavy metal.



Copper the Dog

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Finally, I'm blessed with absolutely extraordinary parents who have cheered me on all the way through my education. I can't thank you both enough for your unwavering love and encouragement. Your support has meant so much to me and I dedicate this thesis to you.

PREFACE

All research presented here was completed for my PhD thesis.

A version of Chapter 3 has been published in the *Australian Journal of Crop Science*.

A version of Chapter 3 was also presented as a poster at the 2019 Ecological Society of Australia's annual conference in Launceston.

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