

Assessment of the feasibility of a new end use in water recycling schemes for urban water

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Doctor of Philosophy

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Certificate of Authorship/Originality

I certify that the work presented in this thesis is, to the best of my knowledge and belief, original, except as acknowledged in the text, and that the material has not been submitted, either in whole or in part, for a degree at this or any other university. In addition, I declare that all information sources and literature used are indicated in the thesis.

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BANDITA MAINALI

.....

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ABBREVIATIONS

ABM	Australian Bureau of Metrology
ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
ADWG	Australian Drinking Water Guidelines
ANOVA	Analysis of variance
ARC	Australian Research Council
ARCWIS	Australian Research Centre for Water In Society
ASTM	American Society for Testing and Materials
AUD	Australian Dollar
AWS	Alliance Water Solutions
BOD	Biochemical Oxygen Demand
C	Cotton
CADS	Citizen Against Drinking Sewage
CFU	Coliform Unit
COD	Chemical Oxygen Demand
COAG	Council of Australian Government
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cu	Copper
CWW	City Waste Water
DAFF	Dissolved Air Flotation and Filtration
De	Denim
df	degrees of freedom
DPR	Direct Potable Reuse
DRS	Dual reticulation System

EDCS	Endocrine Disrupting Chemicals
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organisation
Fe	Iron
GL	Gigalitres
GWA	Global Water Awards
IFPRI	International Food Policy Research Institute
IPR	Indirect Potable Reuse
IUCN	International Union for Conservation of Nature
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
km	kilometres
LSI	Langelier Saturation Index
MAV	Maximum allowable value
Mn	Manganese
MF	Microfiltration
ML	Megalitres
ml	millilitres
NLWRA	National Land and Water Resources Audit
NSW	New South Wales
NWC	National Water Commission
NWQMS	National Water Quality Management Strategy
Pb	Lead
PMRWP	Port Macquarie Reclaimed Water Plant
Po	Polyester
PoC	Polycotton
QLD	Queensland

RHDA	Rouse Hill Development Area
RO	Reverse Osmosis
RW	Recycled Water
S	Satin
SA	South Australia
SEM	Scanning Electronic Microscope
SoE	State of the Environment
SIWI	Stockholm International Water Institute
SOPA	Sydney Olympic Park Authority
SPSS	Software Package for Social Science
STP	Sewage Treatment Plant
SWOT	Strength Weakness Opportunity Threat
TAS	Tasmania
TCC	Toowoomba City Council
TDS	Total Dissolved Solids
TW	Tap Water
TWCM	Total Water Cycle Management
UF	Ultra Filtration
UK	United Kingdom
UN	United Nations
UNDP	United Nation Development Project
UNEP	United Nations Environmental Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific members
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFPA	United Nations Framework for Population Activities
US	United States

US AID	United States Agency for International Development
UV	Ultra Violet
VIA	Virginia Irrigation Association
VIC	Victoria
VPS	Virginia Pipeline Scheme
WA	Western Australia
WBCSD	World Business Council for Sustainable Development
WFT	Water Future Initiatives
WHO	World Health organisation
WSAA	Water Services Association of Australia
WSUD	Water Sensitive Urban Design
WWTP	Waste Water Treatment Plant
Zn	Zinc

TABLE OF CONTENTS

1	INTRODUCTION	1-1
1.1	Overview.....	1-1
1.2	Research objectives	1-4
1.3	Scope of research.....	1-4
1.4	Research approach.....	1-5
2	LITERATURE REVIEW	2-1
2.1	Current status of water resources of the world	2-1
2.1.1	Global water availability.....	2-2
2.1.2	Global water use	2-6
2.1.3	Water availability and use in Australia.....	2-7
2.2	Current solutions to the problems of water scarcity	2-15
2.2.1	Water resources management	2-16
2.2.2	Water recycling.....	2-19
	A. Global water recycling.....	2-20
	B. Water recycling in Australia.....	2-22
2.3	End uses of recycled water	2-24
2.3.1	Persisting end uses of recycled water internationally	2-26
2.3.2	Persisting end uses of recycled water in Australia.....	2-30
2.3.3	Proposed new end use.....	2-33
2.4	Relevant issues in the use of recycled water	2-39
2.4.1	Public perception of recycled water.....	2-39
2.4.2	Risk associated with use of recycled water.....	2-42
2.5	Critical factors in the successful implementation of water reuse schemes.....	2-45
2.5.1	Successful water reuse schemes.....	2-46
	A. Virginia Pipeline Scheme (VPS), Australia.....	2-46

B.	NEWater, Singapore	2-49
2.5.2	Controversial water reuse schemes	2-50
A.	San Diego, United States of America	2-51
B.	Toowoomba, Australia.....	2-53
2.6	Conclusion	2-54
3	RESEARCH METHODOLOGY	3-1
3.1	Introduction.....	3-1
3.2	Methodology for experimental investigation with heavy metals	3-1
3.2.1	Experimental set up and aqueous solution preparation.....	3-1
3.2.2	Testing methods	3-4
A.	Tensile and Tearing strength tests.....	3-4
B.	Colour measurements and colour difference calculation.....	3-5
C.	Scanning Electron Microscope	3-10
3.3	Methodology used for the experimental investigation with recycled water...	3-11
3.3.1	Experimental set up.....	3-11
3.3.2	Testing methods	3-11
A.	Tensile and Tearing strength tests.....	3-12
B.	Colour measurements and colour difference calculation.....	3-13
C.	Scanning Electron Microscope	3-13
D.	Microbial Analysis of Recycled water and cloth samples.....	3-13
E.	Langelier Saturation Index.....	3-14
3.4	Methodology used in formulating the conceptual design factors for educational leaflets	3-15
3.4.1	Community Consultation	3-15
3.5	Methodology used for community attitude survey.....	3-16
3.5.1	Survey plan design and execution.....	3-16

3.5.2	Questionnaire survey and data analysis	3-17
4	INVESTIGATIONS WITH SYNTHETIC WATER FOR DETERMINATION OF MAXIMUM ALLOWABLE VALUES OF HEAVY METALS IN RECYCLED WATER	4-1
4.1	Introduction.....	4-1
4.2	Methodology.....	4-4
4.3	Results and discussion	4-4
4.3.1	Tensile and tearing strength	4-4
A.	Tensile strength	4-5
B.	Tearing strength	4-9
C.	Long wash cycle tests	4-13
4.3.2	Colour difference	4-17
A.	Delta L (ΔL^*).....	4-18
B.	Delta a (Δa^*)	4-19
C.	Delta b (Δb^*).....	4-20
D.	Delta C (ΔC^*)	4-20
E.	Delta E (ΔE^*):.....	4-21
4.3.3	Change in surface structure characteristic of fabric sample	4-26
4.4	Conclusion.....	4-36
5	INVESTIGATIONS OF THE FEASIBILITY OF RECYCLED WATER FOR HOUSEHOLD LAUNDRY	5-1
5.1	Introduction.....	5-1
5.2	Methodology.....	5-4
5.3	Results and discussion	5-4
5.3.1	Providers of recycled water for experimentation.....	5-4
5.3.2	Tensile and tearing strength	5-6
A.	Tensile strength.....	5-6

B.	Tearing strength	5-7
C.	Long wash cycle tests	5-8
5.3.3	Colour difference	5-10
5.3.4	Change in surface morphology of fabric sample	5-14
5.3.5	Microbiological analysis	5-15
5.3.6	LSI calculations	5-19
5.4	Conclusion	5-20
6	EDUCATIONAL LEAFLETS	6-1
6.1	Background.....	6-1
6.2	Fundamental concepts of recycled water for the educational leaflets	6-4
6.2.1	Definition of wastewater	6-5
6.2.2	Organic Matter	6-6
6.2.3	Inorganic matter	6-6
6.2.4	Micro-organisms	6-7
6.2.5	Suspended Particles	6-7
6.2.6	Definition of recycled water	6-7
6.2.7	Sources of Recycled water.....	6-10
A.	Stormwater	6-10
B.	Grey water.....	6-11
C.	Blackwater	6-13
D.	Agricultural and Industrial Wastewater	6-13
E.	Municipal Wastewater	6-14
6.2.8	Treatment methodologies.....	6-14
6.3	Design criteria of educational leaflets for recycled water	6-17
6.3.1	Background	6-17
6.3.2	Methodology	6-19

6.3.3	Results and Discussions	6-20
6.4	Conclusion	6-23
7	COMMUNITY ATTITUDE SURVEY.....	7-1
7.1	Introduction.....	7-1
7.2	Methodology-	7-6
7.2.1	Survey plan design and execution.....	7-6
7.3	Results and Discussion	7-6
7.3.1	General features of three study sites	7-6
7.3.2	Concerns and willingness to use recycled water.....	7-9
7.3.3	Correlation between the variables.....	7-17
7.3.4	Cost of recycled water and information on recycled water	7-22
7.3.5	Feedbacks from the current user of recycled water	7-24
7.4	Conclusions	7-26
8	CONCLUSIONS AND RECOMMENDATIONS	8-1
8.1	Conclusions	8-1
8.2	Recommendations.....	8-3
	REFERENCES.....	R-1
	PUBLICATIONS.....	P-1
	APPENDIX 1.....	A1-1
	APPENDIX 2.....	A2-1

LIST OF TABLES

Table 2.1 One estimate of global water distribution	2-5
Table 2.2 Average annual rainfall in cities of Australia	2-11
Table 2.3 Major Natural Water Resources of Australia	2-12
Table 2.4 Class of recycled water	2-25
Table 3.1 Concentration range of heavy metals in drinking water.....	3-3
Table 3.2 Summarized details of the lab set up.....	3-3
Table 4.1 Tensile strengths with Cu, Fe, Mn, Pb and Zn washings at 10 th wash cycle	4-5
Table 4.2 The change of colour in delta E* calculated by various formulas at different concentration of heavy metals in water in comparison with tap water after 10 wash cycles.....	4-23
Table 4.3 The change of colour in delta E* calculated by various formula at different concentration of heavy metals in water in comparison with tap water after 50 wash cycles.....	4-25
Table 5.1 General characteristics of the recycled water from three providers.....	5-5
Table 5.2 The difference in L*, a* and b* of cloths washed in recycled water from three different providers in comparison with cloths washed in tap water after 10 and 50 wash cycles respectively, expressed as ΔL, Δa and Δb respectively.....	5-12
Table 5.3 The change of colour of cloths washed in recycled water from three different providers in comparison with cloths washed in tap water after 10 and 50 wash cycles respectively, expressed as ΔE* calculated by various formulas	5-13
Table 5.4 Microbiological analysis of cloth samples washed in recycled water.....	5-17
Table 5.5 LSI of aqueous solutions of various concentrations of various heavy metals... ..	5-19
Table 6.1 Sources of wastewater and potential pollutants	6-5
Table 7.1 Percentage of respondents opposing the specific uses of recycled water- Various international studies.....	7-3
Table 7.2 General details of all three study areas.....	7-8

Table 7.3 Wilcoxon Signed Ranks Test for ranking the most preferred condition by the community which would make them more confident to use recycled water in washing machine	7-10
Table 7.4 Correlation between variables	7-19

LIST OF FIGURES

Figure 1.1 Research frameworks.....	1-5
Figure 2.1 Annual rainfall and river discharge globally	2-8
Figure 2.2 Australia’s distribution of run-off.....	2-8
Figure 2.3 Variation in water use in Australia.	2-13
Figure 2.4 Pattern of use of Australian’s water resources.....	2-14
Figure 2.5 Water consumption state and territory 2009/10.....	2-15
Figure 2.6 Reuse water by state in %.....	2-23
Figure 2.7 Tree of water resources recycling.....	2-30
Figure 2.8 Annual per capita water consumption by location of use in 2001.....	2-35
Figure 2.9 Estimated use of water by households in Sydney, Melbourne and Perth ..	2-35
Figure 2.10 Respondents (%) opposed to use of recycled water in washing machines in Australia.....	2-36
Figure 2.11 Willingness to use recycled water for washing clothes.....	2-37
Figure 3.1 Testing methods.....	3-4
Figure 3.2 Instron 6022 10kN Universal Testing Machine interfaced with computer.	3-5
Figure 3.3 Colour plotting diagram for L*, a* and b*.....	3-6
Figure 3.4 Scanning electronic microscope.....	3-10
Figure 3.5 Summarized test methods.....	3-12
Figure 4.1 Tearing strength of cloth samples washed in various concentration of Fe, Pb and Zn solutions and tap water.....	4-12
Figure 4.2 Comparative study of tensile and tearing strengths of cloth samples washed in tap water , 1 mg/L of Fe (a, b), 1 mg/L of Pb (c, d) and 10 mg/L of Zn (e, f) solutions at 10 th , 20 th , 30 th and 50 th wash cycles respectively.....	4-17
Figure 4.3 The change in colour of cloth samples in terms of ΔL^*	4-19
Figure 4.4 The changing colour of cloth samples in Δa^* , Δb^* and ΔC^*	4-21

Figure 4.5 Denim (1000x) after 10 wash cycles in tap water and Cu concentration at 2, 5, 10, 15, 20 mg/L.	4-27
Figure 4.6 Polycotton (1000x) after 10 wash cycles in tap water (a) and Cu concentration at 2, 5, 10, 15, 20 mg/L (b, c, d, e, f).	4-28
Figure 4.7 Cotton (1000x) after 10 wash cycles in tap water and Fe concentration at 0.1, 0.3, 1, 3, 5 mg/L.	4-30
Figure 4.8 Denim (1000x) after 10 wash cycles in tap water and Pb concentration at 0.5 and 2 mg/L.	4-30
Figure 4.9 Cotton (a,b) and Denim (c,d) (1000x) washed in tap water and 30 mg/L of Zn.	4-32
Figure 4.10 Organic cotton (1000x) after 50 wash cycles in tap water (a), in 2mg/L of Mn (b), 2mg/L of Pb (c) and 60mg/L of Zn (d).	4-33
Figure 4.11 Denim (1000x) after 50 wash cycles in tap water (a), in 2mg/L of Mn (b), 2mg/L of Pb (c) and 60mg/L of Zn (d).	4-34
Figure 4.12 Polycotton (3000x) after 10 wash cycles of tap water (a), 1 mg/L of Pb, Fe and Mn (b, c, d), 10 mg/L of Cu (e) and 30 mg/L of Zn (f).	4-36
Figure 5.1 Tensile strengths of cloth samples washed in Tap water (TW) and recycled water from Port Macquarie (PM), Melbourne (Mel) and Sydney (SOPA) at 10 th wash cycle.	5-7
Figure 5.2 Tearing strength of cloth samples washed in tap water and recycled water from three providers.	5-8
Figure 5.3 Comparative study of tensile and tearing strengths of cloth samples washed in tap water (TW), and recycled water from Port Macquarie (PM), Melbourne (M) and Sydney (S) 10 th , 20 th , 30 th and 50 th wash cycles respectively.	5-9
Figure 5.4 Denim (2000x) after 10 wash cycles in tap water and recycled water from PM, M and S respectively.	5-14
Figure 5.5 Cotton (2000x) after 10 wash cycles in tap water and recycled water from PM, M and S respectively.	5-15
Figure 6.1 Natural and synthetic organic matter found in wastewater.	6-6
Figure 6.2 Summary of components of treatment methodologies for recycled water	6-16

Figure 6.3 Range of nominal pore diameters for commercially available membranes...	6-17
Figure 6.4 Preferential factors to be presented in educational leaflets.....	6-21
Figure 7.1 Geographical locations of the survey areas in Port Macquarie and Melbourne, Australia	7-6
Figure 7.2 Willingness to use recycled water for various enduses for three categories of users of recycled water.....	7-11
Figure 7.3 Comparitive analysis of willingness to use recycled water for washing machine among three user categories of recycled water.....	7-14
Figure 7.4 Percentage difference among the three user groups in terms of their willingness to use recycled water for washing machine and to support the new end use.	7-15
Figure 7.5 Concerns of the community regarding the use of recycled water for washing machine.	7-16
Figure 7.6 Percentage of respondents in regards to their opinion about the cost of recycled compared to that of drinking water among the three user groups.	7-23
Figure 7.7 Current use of recycled water for various enduses in Newington.....	7-25

ABSTRACT

Pressure on the availability of Australian freshwater resources is significantly increasing due to emerging climate change and population growth factors. Sustainable urban water consumption has become a critical issue in Australia due to the increasing urbanization, country's dry climate and increasingly variable rainfall. Water recycling is considered vital in alleviating the demand on existing and limited water supplies. It is the process by which wastewater, typically from sewage and/or stormwater collection, is treated to a variety of quality levels depending on the intended use and required safety standards. The benefits of using recycled water include protection of water resources, prevention of coastal pollution, recovery of nutrients for agriculture, augmentation of river flow, savings in wastewater treatment, enhancing groundwater recharge, and sustainability of water resource management. This will help in alleviating the pressure on existing water supplies and on the other hand protects remaining water sources from being polluted. Therefore, demands on water utilities to develop water recycling capacity and supplies are expected to intensify in Australia to cope with the persisting and increasing water stress. Numerous initiatives have been embraced Australia-wide to increase the availability of less-climate dependent water sources. Dual reticulation systems are one of the integral parts of such initiatives. Many cities in Australia are already equipped with dual reticulation system and this is likely to expand in many other cities in the future due to the persisting and increasing water stress. Considerable amount of fresh water conservation has been achieved due to the use of recycled water in urban communities. However, the end uses of the recycled water in such systems are limited and confined to toilet flushing, garden irrigation and car washing. Washing machine involves significant amount of household water (almost 20%) in most of the countries of the world including Australia. In this regards, use of recycled water for washing machine as a new end use of recycled water could be one innovative thought. Hence, this study aims to introduce a new end use to recycled water for urban water.

The recycled water parameters in terms of maximum allowable values of heavy metals in recycled water for laundry were formulated as the result of the study. Vision of community and their major concerns in regards to use of recycled water for washing machine were identified. The investigations with recycled water for washing clothes in washing machines were carried out to address all the major concerns of the general

community regarding this new end use. The results indicated that Class A recycled water being supplied to the dual reticulation systems in urban community is safe for this new end use and highly recommended. The conceptual design criteria of educational leaflets for the dissemination of information on use of recycled water for various end uses were presented. Hence, this study proposes clear pathway to assist the adoption of water reform by actively engaging members of the community in this particular new recycled water application. Public acceptance of this new end use would be a significant step forward into sustainable thinking of urban communities. Conclusively, a new end use for recycled water for washing machines is acceptable and considered as a sustainable approach for Australian urban water.