

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

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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.