# Cost Effective Filtration System to Improve the Water Quality in Rainwater Tanks


**By**

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# Certificate of original authorship

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Candidate: Date:

7 February 2014

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# Nomenclature

| | | |
|---|---|---|
| A | = | Surface area ($m^2$) |
| Å | = | Average pore diameter |
| ABS | = | Australian Bureau of Statistics |
| AC | = | Activated Carbon |
| ADWG | = | Australian Drinking Water Guidelines |
| ANZECC Council | = | Australian and New Zealand Environment and Conservation |
| APAH | = | American Public Health Association |
| ASTM | = | American Standard Testing and Methods |
| BMP | = | Best Management Practice |
| BOD | = | Biological Oxygen Demand |
| BOM | = | Biodegradable Organic Matter |
| $C_b$ | = | The concentration of particles in a feed water |
| $^0C$ | = | Degree Celsius |
| CC | = | Cubic centimetres |
| COD | = | Chemical Oxygen Demand |
| Da | = | Dalton |
| Dia. | = | Diameter |
| DOC | = | Dissolved Organic Carbon |
| DOM | = | Dissolved Organic Matter |
| DMF | = | Dual media filter |
| EfOM | = | Effluent Organic Matter |
| Eq. | = | Equation |
| g | = | Gram |
| G | = | Gravity |
| GAC | = | Granular Activated Carbon |
| hr | = | hour |
| HPSEC | = | High Pressure Size Exclusion Chromatography |
| kg | = | Kilogram |
| kL | = | Kilolitre |
| kPa | = | Kilo Pascal |

| | | |
|---|---|---|
| L | = | Litre |
| m | = | Metre |
| $m^2$ | = | Square metre |
| $m^3$ | = | Cubic metre |
| MFI | = | Modified Fouling Index |
| mg | = | Milligram |
| mL | = | Millilitre |
| mm | = | Millimetre |
| MWD | = | Molecular Weight Distribution |
| MF | = | Microfiltration |
| N/A | = | Not applicable |
| NF | = | Nanofiltration |
| NOM | = | Natural Organic Matter |
| NTU | = | Nephelometric Turbidity Unit |
| Q1 – Q4 | = | Quarter of the year |
| RO | = | Reverse Osmosis |
| RWOM | = | Rainwater Organic Matter |
| SWC | = | Sydney Water Corporation |
| T | = | time (s) |
| TC | = | Total carbon |
| TDS | = | Total Dissolved Solid |
| TIC | = | Total Inorganic Carbon |
| TMP | = | Trans-membrane Pressure |
| TOC | = | Total organic carbon |
| TSS | = | Total Suspended Solids |
| UF | = | Ultrafilter |
| µm | = | Micro metre |
| WHO | = | World Health Organisation |
| yr | = | Year |

# List of Publications

1. B. Kus, D. Pratheep, Jaya Kandasamy, S. Vigneswaran, H. K. Shon, G. Moody (2013) Reduction in water demand due to rainwater tanks in Sydney, Water Management, Proceeding of the institution of Civil Engineers, submitted for publication in February, 2013.

2. B. Kus, J. Kandasamy, S. Vigneswaran, H. K. Shon, and G. Moody (2013) Household rainwater harvesting system – pilot scale gravity driven membrane-based filtration system. Water Science and Technology, 13 (3) 790-797

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# Abstract

Although most Australians receive their domestic supply from reticulated mains or town water there are vast areas with very low population densities with few reticulated supplies (ABS, 2001). In many of these areas, rainwater collected in tanks is the primary source of drinking water. Small amounts of contaminants found in drinking water may have a chronic effect on the health over a human's lifetime due to its cumulative effect. Heavy metals have recently become a major concern as their concentration in stored rainwater was found to exceed recommended levels and proved to be unsuitable for human consumption.

Even in areas that are serviced by town mains water, many households, schools, community and commercial centres collect rainwater in tanks to augment supplies or provide an alternative and sustainable source of water. Widespread water restrictions in cities such as Sydney and Brisbane in recent years have brought to prominence water conservation measures, including the use of rainwater tanks.

The aim of this project is to develop a cost effective filtration system to improve water quality in rainwater tanks.

Pollutants in rain tank water can be generically described as containing colloidal solids, some microbial pollutants and micro-pollutants. The pollutant characteristics of sampled values of rainwater tanks in the Sydney metropolitan and rural areas of New South Wales, Australia, was analysed to determine the critical pollutants and those that do not comply with the Australian Drinking Water Guidelines (ADWG, 2011). The results indicate that before treatment, the rainwater complied with many of the

parameters specified in the ADWG (2011), though as previous studies demonstrate certain pollutants have the potential at times to exceed the limits specified in ADWG (2011). Additionally the characteristics of the first flush of roof runoff and its impact on the quality of water stored in a rainwater tank is presented.

Demand management analysis was conducted using data obtained for residential households throughout Sydney. The analysis provides the water demand for residential households in individual LGAs in Sydney. It also, for the first time, defines the reduction in water demand in all Sydney LGAs as a result of installing rainwater tanks. Such data can be used to size the volume of the permeate storage tank which is an integral element of a rainwater tank treatment system.

An experimental study of an affordable adsorption and membrane based treatment system was carried out. This included investigating the long term performance of GAC adsorption filter as a pre-treatment to micro-filter membrane filtration used to treat raw rainwater.

On completion of laboratory studies, filtration systems were tested to determine the operational performance of various media filter and membrane filter systems at the stormwater harvesting plant at Carlton, Sydney. This plant harvests stormwater baseflow whose quality was comparable to rainwater. The results provide useful information of how a comparable treatment system can treat rainwater.

Finally a gravity driven pilot scale rainwater treatment system was developed and tested in a residential property in Sydney. The results of the performance monitoring of the system is presented. The outcome of the study demonstrated that the water quality in rainwater tanks can be improved through a simple yet effective GAC & membrane

filtration system driven only by the power of gravity leading to a cost effective setup that did not require expensive pumps and automation systems. The filter elements are periodically replaced to provide an ongoing high quality water supply.