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The writer thanks the authors (Ladson and Magyar 2015) for an interesting response to discussion about the publication by Magyar et al. (2014) which reveals some general agreement. However, there are key points of disagreement based on consideration of the detail. Unfortunately, the writer was unable to see or participate in the discussion and response processes until long after publication. As such, this additional discussion necessarily responds to correct some of the statements made about our published work and associated inferences made by the authors.

The authors base their inferences on a key assumption that the behaviour of rainwater harvesting systems is different in urban areas as compared to rural areas. These inferences are derived from a selection of studies and interpretation of results of our national longitudinal investigations. Attempts to define differences between urban and rural rainwater harvesting systems are relevant due to the urban jurisdiction of government-owned water monopolies. More than 1.13 million rainwater harvesting systems (ABS 2013) are now operating as a supplementary source of water within urban areas which may be perceived as competing with monopoly supply of water. State government health departments do not recommend use rainwater for drinking and food preparation where a mains water supply is available (Victorian Government 2013) but are relatively silent on rural areas. In response to the author's concerns about reliable high-quality rainwater in urban areas, the writer highlights more than 111,100 households in capital cities (ABS 2013) are solely reliant on rainwater supplies without widespread health problems which are a focus of this response.

Results from national longitudinal investigations for microbial (Evans 2010; Evans et al. 2009) and elemental observations (Morrow et al. 2007; Morrow 2012) do not indicate significant differences between the characteristics of urban and rural rainwater supplies. The statement by authors that rainwater storages with mains water top up have diluted the concentrations of metals in our research is not correct. A majority of our results are from rainwater harvesting systems that do not include mains water top up systems, including at Figtree Place (Coombes, Argue et al. 2000; Coombes, Kuczera et al. 2000) in Newcastle and from our national observations. It is highlighted by Morrow et al. (2007) that only 23% of rainwater harvesting systems were backed up by mains water and only a small proportion of these systems included mains water trickle top up processes.

Early results for the period July 2006 to July 2007 (87 samples) summarised in Morrow et al. (2007) revealed that rural rainwater supplies contained higher concentrations of iron, cadmium, manganese and copper. In contrast, higher concentrations of strontium, chromium and molybdenum were found in urban areas. However, there were no significant differences between urban and rural rainwater supplies for most elements or metals, including lead. To the clarify the comment by the authors, Morrow et al. (2007) actually reported that eight samples (7.2%) exceeded guideline values from Australian Drinking Water Guidelines (ADWG) for a single sample with no subsequent exceedances in any rainwater harvesting system. Thus, all systems were actually compliant with ADWG because a single exceedance of guidelines values is not classified as harmful or exceedance of the ADWG. Importantly, the relevance of any exceedance of ADWG parameters is also strongly dependent on the location of sampling within the rainwater treatment train and the purposes of the rainwater harvesting system. This critical issue is addressed in this response.

Final results of repeated sampling for the period July 2006 to September 2010 (more than 500 samples), as reported by Morrow (2012), highlighted that concentrations of lead and copper were significantly higher in rainwater harvesting systems (at the tank tap) in industrial areas as compared to rural and urban areas. These samples were compliant with ADWG. Indeed, rainwater harvesting systems in urban areas displayed the lowest relative concentrations of copper and lead. Repeated

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exceedances of guideline values for elements or metals (including lead) were rare.

Similarly, Evans (2010) found no evidence of higher abundance or persistence of bacteria in urban rainwater harvesting systems and subsequent sampling established a higher abundance of bacteria in rural rainwater harvesting systems. The results for faecal indicator bacteria were statistically similar for urban and rural rainwater harvesting systems. Mains water trickle top up systems did not create significant impacts on the bacterial ecology.

In addition, testing for Escherichia Coli (*e. Coli*) in cold water samples indicated that 72% of samples with compliant with ADWG and 98% of samples were compliant with recreational or bathing water guidelines. More than 96% of hot water samples were compliant with ADWG. However, Coombes et al. (2006) and Luo et al. (2011) reported a substantial number of environmental *e. coli* species that are not associated with faecal contamination. Use of *e. coli* as an indicator of possible faecal contamination of environmental waters is likely to result in overestimation of perceived risk. Evans (2010) established that *e. coli* and enterococci was less than 0.01% of bacterial abundance in samples. Nevertheless, the presence of bacterial species that were potentially opportunistic pathogens was identified in 11 samples.

This research also highlighted a level of uncertainty with the highly regarded Polymerase Chain Reaction (PCR) methods for detention of microbes which was confirmed by use of multiple investigation methods to verify the results. There is a need for diligence and care in the interpretation of rainwater testing results and for fit-for-purpose designs of rainwater harvesting systems. These investigations also highlighted that use of leaf diverters were highly effective in reducing bacterial loads, including faecal indictor bacteria, discharging into rainwater storages and that first flush devices provided negligible reductions in bacterial loads.

Our research has revealed a rainwater treatment train (for example: Coombes 2002; Spinks 2007; Morrow 2012) and has confirmed that the quality of rainwater varies at different points in the rainwater harvesting systems from roof to storage to tap (for example: Morrow 2012, Morrow et al. 2010; Evans 2010; Martin et al. 2010; Spinks 2007, Coombes 2002). The assessment of water quality from rainwater harvesting systems is critically dependent on the sample location within the treatment train, position in the rainwater storage and on repeated sampling protocols. It was a key finding by Morrow (2012) and Coombes (2002) that that the general nature of rainwater sampling investigations obscures actual water quality outcomes.

The quality of rainwater delivered by a rainwater harvesting systems should be assessed against the intended use of rainwater. It is disingenuous (for example) to sample the water quality in disused rainwater storage connected to a shed roof that was only intended for infrequent outdoor water use and then extrapolate these results to assumptions about drinking water and associated health risks. The current genre of sampling results and speculation about health risks represents a dichotomy of purposes. Assessments of rainwater quality for different supply options should be based on rainwater harvesting systems intended for those uses and sampling at the point of use. It is also confirmed by our investigations that sampling from rainwater storages or outside taps will provide misleading interpretation of water quality at drinking water taps (for example). It is also a key finding by Morrow et al. (2010) and Spinks (2007) that plumbing, tapware and fittings within the household can sometimes impact on the quality of rainwater (and mains) supplies.

We should also be mindful that urban rainwater harvesting systems have captured a growing proportion of market for otherwise monopoly supply of water, and that servicing and maintenance of urban rainwater harvesting systems is now seen as a new business opportunity for many organisations, especially government owned water authorities. As such, the writer proposes that claims about widespread problems with urban rainwater harvesting systems needs to be carefully evaluated. It is agreed that that there are a range of issues to resolve with the evolution of urban rainwater harvesting systems. Nevertheless, it is not agreed that urban rainwater harvesting systems are substantially worse than those in rural areas as proposed by the authors. The magnitude and consequence of problems with urban rainwater systems implied by the authors is also challenged by the writer.

The writer agrees that the design, maintenance and management of all rainwater harvesting systems should be fit-for-purpose. More awareness of the need for adequate protocols for design and management is certainly required. This will require the industry to move on from a culture of highlighting barriers to rainwater harvesting to a mindset of providing solutions. A rainwater harvesting system intended for drinking water supply (or any other end use) should have an appropriate design and adequate management protocols. These issues are not complex or insurmountable. However, we need to avoid systematically misleading perceptions (such as general inferences about rainwater quality and a perceived difference in urban areas) and strive to understand and resolve core issues.

For example, the writer's rainwater harvesting system is intended for all household water supply (with back up from mains water) and incorporates leaf diverters, fine screens on all inlets and outlets to the rainwater storage, a submerged pump located above the sludge layer (100 mm), a 20 micron filter on the rainwater supply, a hot water service set at greater than 55 °C and a 0.5 micron filter with activated carbon at the kitchen tap. Maintenance of these systems requires occasional cleaning of leaf diverters and mesh screens, and inspection to ensure the system is working. It is envisaged that these types of designs and protocols can be adequately supported by the water industry.

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