Discussion on "Influence of roofing materials and lead flashing on rainwater tank contamination by metals" by Magyar M.I., Ladson A. R., Daiper C., and Mitchell, V.G. 2014. Australian Journal of Water Resources Vol. 18, No. 1, pp 71-83.

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Investigations by the writer established that the quality of rainwater collected from roofs at Figtree Place and nearby houses in Newcastle occasionally exceeded the values from Australian Drinking Water Guidelines for Ammonia, pH and Lead (Coombes et al., 2000; Coombes, 2002). However, no exceedances of the guidelines were observed for chemical and metal parameters including Lead in the water column of the storages or at hot water taps. This discovery suggested that rainwater quality in storages improves because metal and chemical contaminants settle to the bottom of the tanks where they sorb to a biofilm that is commonly known as sludge. Samples taken from the sludge revealed accumulation of Lead (0.033 mg/L) and Iron (0.93 mg/L). This led to the hypothesis that the water treatment processes of flocculation, settlement, sorption and bio-reaction operate in rainwater storages to improve quality of stored rainwater. Rainwater storages are bioreactors with biofilms at the water surface micro layer, on internal walls and at the bottom as sludge. An important insight was that rainwater should not be drawn from the bottom 100 mm of a rainwater tank to maximise the quality of water by avoiding disturbance of the sludge. Field observations and laboratory experiments revealed that a first flush device designed to capture the first 0.25 mm of roof runoff can remove 11% - 94% of dissolved solids and 62% - 97% of suspended solids from the first flush of runoff into a rainwater tank which would limit the inflow of chemicals and metals to stored rainwater.

The hypothesis that biofilms form on the internal walls and at the base as sludge in rainwater storages and act to improve water quality by removing contaminants was confirmed by Spinks et al. (2005) and Spinks (2007). Biofilms were observed to have substantial capacity to remove metals (particularly lead) and bacteria from the water column in a rainwater tanks. The concentrations of heavy metals in biofilms were found to be 2,000 – 10,000 times higher than the average concentrations in the water column and concentrations in the sludge were over 340,000 times the concentration in the water column. Spinks (2007) established that a rainwater harvesting system included an incidental treatment train, rainwater storages acted as bioreactors and the quality of rainwater was stratified within storages.

Evans et al., (2006) discovered that rainwater storages act as balanced ecosystems in a similar fashion to environmental systems that improve water quality. The ecosystem includes biofilms (and sludge) that bio-accumulates particles (including metals, chemicals and bacteria) that are bound within "sticky" polysaccharides that also protect from external challenges such as lower pH. Human disturbances (such as "cleaning" of tanks), poor design choices (inlet to pump at the base of the tank) and interference for research purposes (such mixing the last 50 mm of water and sludge as described by the authors) eliminate the cohesiveness of the sludge layer. Experiments that examine the re-suspension of introduced soils or sands that are not part of established and undisturbed biofilms are also unlikely to reproduce the behaviour of rainwater storages.

Spinks (2007) concludes that settlement of particulate matter to the bottom of rainwater tanks is probably the single most beneficial process within rainwater storages. The rates of accumulation of sludge vary widely between rainwater harvesting systems (1 mm to 8 mm/year) and are not necessarily related to quality of sludge (particularly for heavy metals). Sludge can contain highly magnified concentrations of some heavy metals (in particular lead), and to a lesser extent, bacteria. Nevertheless, sludge does not generally resuspend into the water column during rain events. As such, the practice of de-sludging or cleaning may provide a marginal improvement to water quality and may reduce the risk of a compromise to water quality on occasions when re-suspension does occur, though is not widely practiced and is not essential to the maintenance of high quality tank water. The quality of rainwater supplies was not compromised by the accumulation of sludge in tanks. This confirms the observation by Coombes (2002) that it is preferable to avoid disturbing rainwater storages.

The authors have not established a link between quality of rainwater and the quality of sludge in undisturbed rainwater storages. Have the disturbances of rainwater storages in the research program substantially altered processes in comparison to the actual phenomena of the undisturbed rainwater harvesting systems? Do the model roofs and storages represent the behaviour of real rainwater harvesting systems? For example, the authors assert that lead is common in rainwater but acknowledge that selected publications find less pessimistic results. However, a body of research not acknowledged by the authors includes unique long term and repeated observations by Spinks (2007) (30 systems) and Morrow et al. (2007) (40 systems) of undisturbed rainwater harvesting systems.

A majority of the rainwater harvesting systems in these investigations were compliant with the chemical and metal values in Australian Drinking Water Guidelines. The use of repeated independent sampling is important for the reliable determination of the concentrations of elements in rainwater harvesting systems. Moreover, Australian Drinking Water guidelines specify that that repeated exceedances of guidelines values for chemicals and metals are classified as a failure – a single exceedance may not be a health risk.

About 12% of samples exceeded guideline values for one or more element. However, in many cases, where a sample was found to exceed guideline values for an element, subsequent samples from the same site were found to be within guideline values for the same element. This could be the result of one of several different processes. The concentrations of various elements in tank water are usually rainfall dependent with concentrations usually higher immediately following rain events. Continuous sampling by Martin et al. (2010) observed that concentrations of bacteria and elements increased immediately after rainfall and declined to baseline concentrations thereafter. These studies highlighted the variability of the elemental composition of collected rainwater between different study sites, at different times and at different sampling points in the rainwater system. Piping materials, lead solder, lead flushing and taps were shown to contribute significantly to the total elemental load at a small number of locations. It is significant that these investigations revealed that the concentrations of chemicals and metals were similar in urban and rural areas.

The authors imply that the accumulation of sludge in rainwater tanks is a threat to acceptable rainwater quality and recommend a maintenance solution – regular cleaning of rainwater harvesting systems. In contrast, additional evidence presented by the writer indicates that rainwater harvesting systems function as ecosystems that are reliant on good design choices and a minimum of disturbance.

The importance of including the full spectrum of historical science in our management reactions was highlighted at the recent Rainwater Harvesting Association of Australia conference in Sydney. Whilst a majority of rainwater harvesting systems were reported to be operating well by the New South Wales government, there were a small proportion of systems that displayed issues with poor water quality. It is important that submerged pumps draw rainwater from above the sludge layer (about 100 mm above the base of the tank) rather than from the bottom of the tank. Similarly, the design of charged or wet rainwater harvesting systems should not store rainwater with organics in pipes between rainfall events that ultimately discharge poor water quality into tanks at the commencement of a rain event.

We should be mindful that rainwater is an important source of water supply - 2.41 million households use rainwater harvesting systems and 0.89 million households are reliant on rainwater for drinking water supplies throughout Australia (ABS, 2013). Regular maintenance of rainwater harvesting systems is carried out at 58% of households and 29% of systems experienced a problem that was resolved in the past year. There has been no reported health epidemics created by rainwater harvesting systems. In addition, the 1.13 million rainwater harvesting systems in urban areas made a substantial contribution to ensuring Australian cities did not exhaust water supplies during the last drought (Coombes and Barry, 2014).

The writer is unsure that the results of a smaller model can be directly presented as reality scale results. Are the authors aware of dimensional and dynamic similitude effects on the scaling of results from the model to reality?

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