Potential Health Risks Associated with the Use of Roof-Harvested Rainwater

Simon Toze (for Warish Ahmed)
Health Risk Assessment of Local Source Waters

Science Forum, 19-20 June 2012
Roof-Harvested Rainwater System
Advantages of using RHRW

(1) Reducing the pressure of the mains water supply
(2) Reducing stormwater runoff that can often degrade creek ecosystem health
(3) Providing an alternative water supply during times of water restrictions

- In 2006, the Queensland State Government initiated the “Home WaterWise Rebate Scheme” which provided subsidies to SEQ residents who used rainwater for non-potable domestic uses
- More than 260,000 householders were granted subsidies by December 2008 when the scheme was concluded
Sources of Faecal Pollution in Rainwater Tanks

- Birds
- Possums
- Lizards
- Frogs
- Snakes
- Fruit bats
Health Risk Associated with the Exposure to Pathogens in Rainwater Tanks

<table>
<thead>
<tr>
<th>Pathogens</th>
<th>Health risks</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Campylobacter</em> spp.</td>
<td>Diarrhoea, abdominal pain and fever</td>
</tr>
<tr>
<td><em>Salmonella</em> spp.</td>
<td>Diarrhoea, abdominal pain and fever</td>
</tr>
<tr>
<td><em>Giardia lamblia</em></td>
<td>Diarrhoea, abdominal pain</td>
</tr>
<tr>
<td><em>Cryptosporidium parvum</em></td>
<td>Watery diarrhoea</td>
</tr>
</tbody>
</table>
 Reported Cases Associated with the Consumption of Rainwater

<table>
<thead>
<tr>
<th>Country</th>
<th>Disease causing pathogens</th>
<th>Types of diseases</th>
<th>No. of people affected</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>C. botulinum</td>
<td>Not specified</td>
<td>3</td>
<td>Murrell and Stewart (1983)</td>
</tr>
<tr>
<td>Australia</td>
<td>Campylobacter fetus</td>
<td>Diarrhea, vomiting</td>
<td>1</td>
<td>Brodribb et al. (1995)</td>
</tr>
<tr>
<td>Australia</td>
<td>Campylobacter spp.</td>
<td>Diarrhea, abdominal pain,</td>
<td>23</td>
<td>Merritt et al. (1999)</td>
</tr>
<tr>
<td>Australia</td>
<td>S. Typhimurium phage 9</td>
<td>Diarrhea, abdominal pain, nausea</td>
<td>27</td>
<td>Franklin et al. (2009)</td>
</tr>
<tr>
<td>New Zealand</td>
<td>S. Typhimurium phage I</td>
<td>Diarrhea</td>
<td>2</td>
<td>Simmons and Smith (1997)</td>
</tr>
<tr>
<td>New Zealand</td>
<td>L. pneumophila</td>
<td>Legionnaires’ disease</td>
<td>1</td>
<td>Simmons et al. (2008)</td>
</tr>
<tr>
<td>U.S. Virgin Islands</td>
<td>L. pneumophila serogroup I</td>
<td>Legionnaires’ disease</td>
<td>27</td>
<td>Schlech et al. (1985)</td>
</tr>
<tr>
<td>West Indies</td>
<td>S. arechevalata</td>
<td>Diarrhea, headache, fever, vomiting</td>
<td>48</td>
<td>Koplan et al. (1978)</td>
</tr>
</tbody>
</table>

In contrast, the most credible epidemiological study reported that the consumption of rainwater did not increase the risk of gastroenteritis among young children in South Australia (Heyworth et al. 2006)
Research Aims

- To quantify the numbers, frequency of occurrence and survival of faecal indicators and pathogens in a range of domestic rainwater tanks in SEQ

- To apply Quantitative Microbial Risk Assessment (QMRA) in order to estimate the risk of infection from exposure to pathogens in rainwater tanks
Selection and Survey of Rainwater Tanks

- 80 rainwater tanks were selected representing 34 suburbs in Brisbane and the Gold Coast

- In addition, 24 samples were collected from the household taps fed by rainwater tanks

- Information on the presence of overhanging trees, faecal droppings on the roof, the gutter condition and uses of RHRW were also recorded
Faecal Indicators and Pathogens Tested in this Study

Faecal indicators:
- E. coli
- Enterococci

Pathogens:
- Salmonella spp.
- Campylobacter spp.
- Cryptosporidium parvum
- Giardia lamblia
Rainwater and Tap Water Sampling

From the selected tanks \( n = 80 \) and household taps \( n = 24 \), 20 L of water samples were collected for microbiological analysis.
Possum and bird faecal sampling

Possum faecal samples were provided by Peter the Possum man.

Bird faecal samples were collected from the botanical gardens and a wildlife sanctuary.
Numbers of Faecal Indicators in rainwater Tanks ($n = 80$)

**E. coli**

Above guideline value

**Enterococci**
Numbers of Pathogens in Rainwater Tanks ($n = 80$)

- **Campylobacter spp.**: 15% with 5-110 cells/L
- **Salmonella spp.**: 1% with 7,300 cells/L
- **G. lamblia**: 8% with 110-140 cysts/L
- **C. parvum**: 0%
Occurrence of Pathogens in Rainwater Tanks and Connected Household taps

- **Campylobacter spp.**: 5 - 100 (rainwater tanks) and 10 - 19 (household taps) cells per L of water.
- **Salmonella spp.**: 7,300 (rainwater tanks) cells per L of water.
- **G. lamblia**: 120 – 580 (rainwater tanks) and 110 – 140 (household taps) cysts per L of water.
- **C. parvum**: 0% (rainwater tanks) and 0% (household taps)
Numbers of Pathogens in Possums ($n = 40$) and Birds ($n = 38$)

*Campylobacter* spp. 24-61% ($6.6 \times 10^4$ to $2 \times 10^7$)

*C. parvum* 5-13% (not quantifiable)

*G. lamblia* 13-30% ($1.3 \times 10^0$ to $1.6 \times 10^3$)
### Microbial Source Tracking in Rainwater Tanks

Occurrence of *Escherichia coli* harbouring toxin genes in rainwater tanks, bird and possum faecal samples

<table>
<thead>
<tr>
<th>Samples</th>
<th>No. of isolates</th>
<th>% harbouring toxin genes</th>
<th>ST1</th>
<th>east1</th>
<th>cdtB</th>
<th>cvaC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainwater tanks</td>
<td>200</td>
<td>22%</td>
<td>4%</td>
<td>13%</td>
<td>10%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Birds</td>
<td>214</td>
<td>23%</td>
<td>ND</td>
<td>14%</td>
<td>5%</td>
<td>8%</td>
</tr>
<tr>
<td>Possums</td>
<td>214</td>
<td>35%</td>
<td>ND</td>
<td>35%</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

ND: Not detected.
Microbial Source Tracking in Rainwater Tanks

% of E. coli isolates

- Birds: 33%
- Possums: 21%
- Unknown: 51%
**E. Coli and Enterococcus spp. in Rainwater Tank samples (N=50): Comparison between Culture Methods and QPCR Assays**

![Graph showing comparison between EPA methods and qPCR for E. coli and Enterococcus spp.](image-url)
Inactivation of Faecal Indicators in the Gutter

The diagram shows the inactivation of faecal indicators (E. coli and Enterococcus sp.) in clean and dirty gutters over time. The data is plotted against Log10 cfu/mL on the y-axis and time (hours) on the x-axis. Temperature is also shown on the right y-axis.
Inactivation of faecal indicators on the roof
Inactivation of faecal indicators in tank water

![Graph showing inactivation of faecal indicators in tank water](image)
Inactivation kinetics of *Escherichia coli* and *Enterococcus* spp. in faecal slurries and tank water

<table>
<thead>
<tr>
<th>Faecal indicators</th>
<th>Experiment types</th>
<th>Kh (T90)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. coli</em></td>
<td>Roof-sunlight</td>
<td>1.7 h</td>
</tr>
<tr>
<td></td>
<td>Roof-shade</td>
<td>111 h; 9 h</td>
</tr>
<tr>
<td></td>
<td>Clean gutter</td>
<td>48 h; 3 h</td>
</tr>
<tr>
<td></td>
<td>Dirty gutter</td>
<td>40 h; 6 h</td>
</tr>
<tr>
<td></td>
<td>Tank water</td>
<td>72 h; 273 h</td>
</tr>
<tr>
<td><em>Enterococcus</em> spp.</td>
<td>Roof-sunlight</td>
<td>2 h</td>
</tr>
<tr>
<td></td>
<td>Roof-shade</td>
<td>199 h; 12 h</td>
</tr>
<tr>
<td></td>
<td>Clean gutter</td>
<td>2 h</td>
</tr>
<tr>
<td></td>
<td>Dirty gutter</td>
<td>6 h</td>
</tr>
<tr>
<td></td>
<td>Tank water</td>
<td>38 h; 195 h</td>
</tr>
</tbody>
</table>
Key Findings

- 70% of the tanks exceeded the drinking water guideline value of 0 *E. coli* per 100 mL of water.

- *G. lamblia* and *Campylobacter* spp. were reasonably prevalent in RHRW tanks and connected taps.

- *C. parvum* could not be detected in rainwater tanks and connected tap water samples.

- Possums and bird faecal samples were positive for *G. lamblia* and *Campylobacter* spp.
  - confirms the fact that possum and bird faeces are the contributing factors.
Key findings

- *E. coli* toxin gene analysis identified bird and possum faeces as potential sources of *E. coli* harbouring toxin genes in rainwater tanks.

- qPCR measurement of faecal indicators yielded higher numbers compared to culture based methods.

- Faecal indicators inactivation: Sunlight > Shade > Rainwater tanks.
Next Steps

Data input into health risk model

Estimation of risk of infection

Synthesis of results and report writing (June 2012 – September)

Journal publications/workshop
Publications


Acknowledgements

- Residents of SEQ for providing access to rainwater tanks
- Peter the Possum Man and Currumbin Wild Life Sanctuary for proving animal faecal samples
- Rainwater and Stormwater Reference Panels for providing suggestions and technical expertise

THANK YOU

www.urbanwateralliance.org.au