Roof-Collected Rainwater Consumption and Health

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Abstract

In a 5-year Massey University study in which the microbiological quality of roof-collected rainwater samples of 560 private dwellings in New Zealand was investigated we found that at least half of the samples analysed exceeded the acceptable standards for contamination and in more than 40% of the samples evidence was found of heavy faecal contamination. The likely sources of the faecal contamination were faecal material deposited by birds, frogs, rodents and possums, and dead animals and insects, either on the roofs or in the gutters, or in the water tank itself. Many of the organisms isolated from contaminated roof water may be pathogenic to humans and can result in gastrointestinal infections caused by organisms such as *Salmonella*, *Campylobacter*, *Giardia* and *Cryptosporidium*. However, the health risks from the likely exposure to these pathogens when using roof-collected rainwater for primary (potable) purposes has not been adequately defined or quantified since public health surveillance data do not reflect the true rate of waterborne illnesses in the community. In this paper we present the results of a systematic review of the evidence regarding the consumption of roof-collected rainwater and health. For this review we have only considered the published disease outbreak reports and epidemiological studies that were predominantly associated with roof-collected rainwater consumption and excluded reports and studies that dealt with other forms of rainwater collection and storage.

Introduction

In New Zealand more than 10% of the population depends on roof-collected rainwater systems for their drinking water - especially in rural areas that are not served by municipal town water supplies. Roof-collected rainwater consumption is also popular because the general public has the perception that rainwater is “pure” and safe to drink. Indeed, the risk of disease arising from roof-collected rainwater consumption can be low, providing that the water is visibly clear, has little taste or smell and, most importantly, the storage and collection of rainwater is via a properly maintained tank and roof catchment system. The microbiological quality of stored roof-collected rainwater can be impacted directly by the roof catchment and subsequent run-off contamination, via direct depositions by birds and small mammals, decay of accumulated organic debris, and deposition of airborne micro-organisms.

The hazards associated with roof-collected rainwater harvesting include:

- Death or injury- especially when using ladders to clean gutters.
• Drowning or near-drowning – especially if children gain access to tanks.
• Asphyxiation – especially when cleaning out rainwater tanks.
• Poisoning – from using unsuitable tank or roofing materials.
• Infection – the possible modes of transmission are listed below.

Pathogens from contaminated roof-collected rainwater can be transmitted by:
• Direct or indirect ingestion of contaminated roof water and foods
• Inadvertent contact through ingestion or inhalation of aerosols produced as a result of toilet flushing and gutter cleaning.
• Direct or indirect ingestion via the garden tap.
• Direct contact through using the tap to fill up swimming pools, paddling pools, hot water tubs, car washing, and washing implements and equipment.
• Inhalation / ingestion and microbial contamination of the environment and subsequent ingestion of garden produce contaminated as a result of watering with roof-collected rainwater.
• Bites from mosquitoes breeding in rainwater tanks.

In order to determine the associations between roof water harvesting and health this review considers the following issues:
• Microbiological quality of roof-collected rainwater.
• Indicator organisms and health relationships.
• Pathogens isolated from roof-collected rainwater and disease outbreaks.
• Health risk studies associated with roof water consumption.

**Microbiological Quality of Roof-collected Rainwater**

Although roof-collected rainwater supplies serving less than 25 people in New Zealand are classified as unregistered supplies and therefore not monitored regularly, a number of reports have been published on the microbiological quality of these private supplies. A study by Dennis (2002) on 60 roof-collected rainwater samples from the South Wairarapa, where approximately 60% of the households use roof water, revealed *E.coli* transgressions in all samples on at least one occasion during a three-month period. Most samples had total coliform counts of more than 500 per 100 ml and in two samples *E.coli* counts of greater than 880 per 100 ml were found. In a pilot study (Sedouch, 1999) on 100 roof-collected rainwater samples from the lower half of the North Island, only 18% of samples were found to comply with the New Zealand Drinking Water Standards and 40% of samples were found to have failed “badly” with very high *E.coli* counts (>2419.6 per 100 ml).

Of 125 roof-collected rainwater samples from rural Auckland districts analysed between 1996 and 1998, 56% had faecal coliform levels that would have exceeded the 1993 WHO drinking water guidelines (Simmons et al. 2001a). Significantly *Aeromonas* spp. was found in 16% of the samples leading the authors to conclude that this organism has potential as an alternative indicator of water quality and health risk.

In a 5 - year Massey University study (Abbott et al. 2006) we investigated the microbiological quality of roof-collected rainwater samples of 560 private dwellings in New Zealand. At least half of the samples analysed exceeded the acceptable standards for contamination and in more than 40% of the samples we found evidence of heavy faecal contamination. The likely sources of the faecal contamination were faecal material deposited by birds, frogs, rodents and possums, and dead animals and insects, either on
the roofs or in the gutters, or in the water tank itself. Importantly, many of the roof water supplies surveyed revealed deficiencies in the use of rainwater catchment systems and components. In a significant number of supplies where we found heavy faecal contamination there was evidence of lack of maintenance; inadequate disinfection of the water; poorly designed delivery systems and storage tanks; and failure to adopt even simple physical measures to safeguard the water against microbiological contamination.

Several overseas studies have also shown that roof-collected rainwater frequently failed drinking water standards with respect to coliforms and/or faecal coliforms values:

- In a survey of the water quality of 100 private farm rainwater supplies in Australia varying levels of total coliforms were found in 52% of the water samples and 38% showed the presence of E.coli as well (Verrinder & Keleher, 2001). However, the authors found no relationship between drinking water quality or drinking water-related health risks on the farms and concluded that although many of the water samples were non-compliant it did not necessarily mean there was a health risk to the householders.

- An intensive monitoring programme of the “Healthy Home” in southeast Queensland showed that while roof water and in situ tank water exceeded the Australian Drinking Water Guidelines (NHMRC, 1996) for total and faecal coliforms by a considerable margin (average tank counts of 830 and 120 per 100 ml respectively), the water quality from the hot water systems consistently produced zero (compliant) levels of total and faecal coliforms (Coombes et al. 2000). This study also revealed that in rainwater cisterns, the highest counts occurred immediately after major rainfall events (≥ 50 mm) which washed organic material from the roof gutters into the tanks. Nevertheless, the authors demonstrated a marked reduction in the bacterial counts over time suggesting that the rainwater cisterns have a self-disinfection action.

- A study by Levesque et al. (2008) on the microbiological quality of drinking water from 102 household rainwater tanks in Bermuda showed that 90% of the samples were contaminated with total coliforms in concentrations exceeding 10 cfu per 100 ml and 66% of samples were contaminated with E.coli. (range 0 - >100). The authors reported that tank cleaning in the year prior to sampling seemed to protect the water from contamination.

- In a three year study in the Netherlands, Schet et al. (2010) demonstrated that roof-collected rainwater was frequently faecally contaminated and incidentally contained potential pathogens such as Campylobacter, Cryptosporidium, Giardia, Aeromonas hydrophila and Legionella. Analysis of samples during a period with variable weather conditions showed a correlation between rainfall intensity and faecal coliform counts (range 0 – 1934) and increased detection of pathogens after heavy rainfall incidents.

- Several other detailed overseas investigations have also raised concerns when they revealed that in many instances stored rainwater does not meet WHO, EPA or other similar standards with respect to one or more bacteriological water quality indicators (Fujioka & Chinn, 1987; Haebler & Waller, 1987; Krishna, 1989).
northeast Thailand, where several million people use rainwater tanks, a major study of rainwater quality by Wirojanagud et al. (1989) on 189 rainwater storage tanks, revealed that only around 40% met WHO drinking water standards. Fewtrell and Kay (2007) reviewed the microbial quality of rainwater supplies in developed countries and found that harvested rainwater supplies varied widely in terms of microbial quality and consistently failed drinking water standards.

**Indicator Organisms and Health Relationships**

In a recent study on the suitability of *Escherichia coli*, *Enterococci*, and *Clostridium perfringens* for assessing the microbiological quality of roof-collected rainwater, Ahmed et al. (2010) showed that the presence or absence of pathogens did not correlate with any of the faecal indicator bacterial concentrations. These authors questioned the reliability of faecal indicators since the roof water samples tested in the study appeared to be of poor microbiological quality but no significant correlation was found between the concentration of faecal indicators and pathogenic organisms.

Evans et al. (2007) has also questioned the relevance of faecal indicator organisms and has suggested the need for a broader approach to the assessment of rainwater tank water quality, especially the likely role of environmental organisms in regulating tank water quality.

Moe et al. (1991) showed that the incidence of diarrhoea in young children was significantly related to drinking water containing high levels of bacterial contamination (>100 *E.coli* per 100 ml) but little difference was observed between illness rates of children using either good quality drinking water (<1 *E.coli* per 100 ml) or moderately contaminated drinking water (2-100 *E.coli* per 100 ml).

Similarly, in a study that investigated the association between *E.coli* and in household drinking water and diarrhoeal diseases in Cambodia, Brown et al. (2008) found that diarrhoeal disease risks did not increase progressively in magnitude with increasing concentrations of *E.coli* in drinking water. Compared to households with <1 *E.coli* per 100 ml in drinking water there was no observed increased risk for having 1-10 *E.coli* per 100 ml while households with measured *E.coli* of 11 to 100 per 100 ml reported a slight increase in diarrhoea. The authors of this study conclude that the continued use of *E.coli* as a basis for decision-making about water quality, water treatment and overall water handling practices needs to be re-examined in light of the growing body of evidence that suggests that *E.coli* may be a poor indicator of waterborne disease risks in at least some settings.

While the coliform group of organisms have been used as indicators for almost 100 years, research is on-going to find better ways to assess the microbiological quality of drinking water, including new detection methodologies such as molecular techniques (Yates 2007). However, in a recent review of the literature analysing a dataset of 540 pathogen-indicator relationships published during 1970-2009, Wu et al. (2011) found that while only 41% showed correlations between indicators and pathogens they concluded that the poor correlations were the result of studies with insufficient data for assessing such correlations. Recently too Levy et al. (2012) were able to detect some associations between *E.coli* in household drinking water quality and diarrhoeal disease
but also suggest that larger sample sizes are needed to account for the inherent variability in water quality exposure measurements using indicator organisms.

Although there is currently considerable debate regarding the public health significance of total coliforms in drinking water, it is important to note that in all waterborne outbreaks between 1991 and 1998 in the USA in which a bacterial agent was identified as the cause of disease, total coliforms were present in all the water samples and they were also detected in 81% of water samples from outbreaks caused by viruses and in 50% of samples where protozoa were responsible for the outbreaks (Craun et al. 2002). Therefore in spite of the controversies concerning the effectiveness of faecal coliforms as indicators of disease risk, these indicator organisms can still be extremely useful for determining contamination of water supplies, including seasonal changes in water quality as well as useful for assessing the success of water treatment methods and preventative maintenance and design systems.

**Pathogens Isolated from Roof-collected Rainwater and Disease Outbreaks linked to Contaminated Roof Water:**

While rainwater itself is free from pathogens and contamination levels of stored rainwater are generally low if tanks are well protected with covers or lids, obvious sources of contamination of the rainwater runoff from roofs and gutters are from birds, possums, rodents, cats and rotting vegetation. Bacterial pathogens such as *Salmonella* spp., *Campylobacter* spp., *Legionella* spp., and *Clostridium perfringens* have been isolated, in varying densities, from roof-collected rainwater samples (Broadhead, 1988; Wirojanagud et al. 1989; Fujioka et al. 1991; Lye, 1992; Lye, 2002; Brodribb et al. 1995; Simmons et al. 2001a).

Savill et al. (2001) found the presence of Campylobacter by an MPN/PCR technique in 5% of roof water samples collected from rural locations in the North Island. Although the numbers of Campylobacter detected were very low, there was no correlation between the presence of Campylobacter and faecal coliform and *E.coli* indicator counts.

In a study on 45 water samples of roof water cisterns in the United States, Crabtree et al. (1996) revealed that 48% were positive for *Cryptosporidium* (mean = 2.4 oocysts/100 L) and 26% positive for *Giardia* (mean =1.09 cysts/100 L). In contrast, in a New Zealand study by Simmons et al. (2001a) on 50 roof-collected rainwater samples, *Cryptosporidium* oocysts were detected in only 2 (4%) of samples and no *Giardia* cysts were found in any of the samples. The authors of the latter study suggest that the difference in the results of the two studies may reflect differences in the prevalence of the protozoa in the animal reservoirs, the sources, and the degree and frequency of faecal contamination of the catchment or rainwater storage tank.

The epidemiological and outbreak studies considered for this review paper includes only those studies where a proportion of the individuals have definitely consumed roof-collected rainwater in the true sense of the words. Studies that were not included in this review are those of reports where individuals put out available collection vessels such as buckets and barrels whenever it rained or reports where the roof water collected was a secondary source connected to a primary mains water (reticulated) receiving underground tank vulnerable to wastewater and sewage contamination. For this review
the outbreak classification system of Tillet et al. (1998) has been used to define the strength of association between roof-collected water consumption and illness (Table 1).

<table>
<thead>
<tr>
<th>Strength of association</th>
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</thead>
<tbody>
<tr>
<td><strong>Microbiology</strong></td>
</tr>
<tr>
<td>Pathogen identified in patient is also found in water</td>
</tr>
<tr>
<td>Indicator organisms and/or water-treatment problem of relevance but outbreak pathogen is not detected in water</td>
</tr>
<tr>
<td><strong>Epidemiology</strong></td>
</tr>
<tr>
<td>PLUS</td>
</tr>
<tr>
<td>Analytical epidemiology (case control or cohort) study demonstrates association between water and illness</td>
</tr>
<tr>
<td>Descriptive epidemiology suggests that the outbreak is water related and excludes obvious alternative explanations</td>
</tr>
</tbody>
</table>

Table 1: Classification system for categorizing strength of association

The 11 roof water disease outbreaks reported between 1978 and 2010 that were considered for this review are shown in table 2.

![Image of Disease Outbreaks]

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Cases</th>
<th>Organism</th>
<th>Association</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>Trinidad</td>
<td>63</td>
<td>Salmonella</td>
<td>Strong</td>
</tr>
<tr>
<td>1981</td>
<td>Caribbean</td>
<td>13</td>
<td>Legionella</td>
<td>Probable</td>
</tr>
<tr>
<td>1983</td>
<td>England</td>
<td>257</td>
<td>Campylobacter</td>
<td>Possible</td>
</tr>
<tr>
<td>1992</td>
<td>Australia</td>
<td>89</td>
<td>Giardia &amp; Cryptosporidium</td>
<td>Possible</td>
</tr>
<tr>
<td>1997</td>
<td>New Zealand</td>
<td>4</td>
<td>Salmonella</td>
<td>Strong</td>
</tr>
<tr>
<td>1999</td>
<td>Australia</td>
<td>23</td>
<td>Campylobacter</td>
<td>Probable</td>
</tr>
<tr>
<td>2000</td>
<td>Australia</td>
<td>28</td>
<td>Salmonella</td>
<td>Strong</td>
</tr>
<tr>
<td>2003</td>
<td>New Zealand</td>
<td>5</td>
<td>Salmonella</td>
<td>Strong</td>
</tr>
<tr>
<td>2006</td>
<td>New Zealand</td>
<td>4</td>
<td>Legionella</td>
<td>Strong</td>
</tr>
<tr>
<td>2009</td>
<td>Australia</td>
<td>27</td>
<td>Salmonella</td>
<td>Strong</td>
</tr>
<tr>
<td>2010</td>
<td>New Zealand</td>
<td>93</td>
<td>Norovirus</td>
<td>Probable</td>
</tr>
</tbody>
</table>

Table 2: Disease outbreaks associated with roof-collected rainwater

Koplan et al. (1978) postulated roof-collected rainwater as possible cause of a 63-case outbreak of Salmonellosis in Trinidad, West Indies, and Simmons and Smith (1997) reported roof-collected rainwater as the probable source of Salmonella Typhimurium infections in a family of four in New Zealand. An investigation of an outbreak of *Salmonella enterica* serotype Typhimurium DT160 infections in humans in New Zealand (Thornley et al. 2003) found that 5 of the 170 case-patients had consumed roof-collected rainwater in which the pathogen was also detected. In an investigation of 28
cases of gastroenteritis among 200 workers at a construction site in Queensland, *Salmonella* Saintpaul was isolated from both cases and rainwater tank samples (Taylor *et al.* 2000). Animal access was suggested as being the source of the contamination with several live frogs being found in one of the suspect tanks. Recently an outbreak of gastroenteritis was identified at a school camp in rural Victoria, Australia (Franklin *et al.* 2009). Environmental and epidemiological investigations suggested that rainwater collection tanks contaminated with *Salmonella Typhimurium* definitive phage type 9 (DT9) was the cause of the outbreak.

Contamination of an open-topped water storage tank by faecal material from birds or bats was the most likely source of infection in an outbreak of *Campylobacter* gastroenteritis that affected 234 pupils and 23 staff at a UK boarding school over a period of 8 weeks (Palmer *et al.* 1983). An outbreak of *Campylobacter enteritis* on a resort island in North Queensland involving 23 cases was probably due to the consumption of contaminated rainwater (Merrit *et al.* 1999).

In 2006, an outbreak of Legionnaires’ disease (LD) was identified in Beachlands, a small, isolated east Auckland suburb (Simmons *et al.* 2008). Aerosols containing Legionella discharged to air by a marina water blaster may have infected some of the cases directly or may have seeded roof-collected rainwater systems resulting in some of the cases being exposed by contaminated bathroom showers. The authors recommend that roof-collected rainwater systems need appropriate design, careful cleaning and the maintenance of hot water temperatures at a minimum of 60°C to reduce the chances of *Legionella* multiplying. Twenty-seven cases of Legionnaires’ disease were identified in 1981 in persons who had stayed at a single hotel in St Croix. The outbreak was due to *Legionella pneumophila* serogroup 1 and 3 several new *Legionella* species were also isolated from the potable water system at the hotel. Following hyperchlorination of the potable water system, no further cases of Legionnaires’ disease in hotel visitors were reported (Shlech *et al.* 1985).

An underground rainwater storage tank was associated with a mixed outbreak of cryptosporidiosis and giardiasis in Australia in which eighty-nine people supplied with the drinking water became ill (Lester 1992). Investigations revealed that the tank had been contaminated by an overflow from a septic tank.

In 2009, 93 cases of Norovirus gastroenteritis were reported among Turoa Ski Field staff on Mount Ruapehu in the North Island of New Zealand (O’Connor *et al.* 2010). Although Norovirus genotypes 1 and 2 were detected in an untreated drinking water sample no Norovirus nor *Escherichia coli* were detected in the rainwater tanks at the ski field. Since norovirus is usually found in humans, and sometimes in pigs, humans were the only possible source of the virus in this outbreak. Because considerable snow-making occurs at the base of the ski field and some of this snow often lands on the roofs of buildings and as the water for the snow is sourced from a pond below the ski area it was hypothesized that contamination of the pond water with human sewage was the source of the outbreak. However, no faecal coliforms were detected in any of the rainwater storage tanks.
**Health Risk Studies Associated With Roof Water Consumption.**

Apart from the few roof water-linked disease outbreaks described above, evidence of actual disease outbreaks resulting from drinking roof-collected rainwater polluted by pathogens is rare. The lack of reports linking communicable disease outbreaks to roof-collected rainwater, may in part be due to the fact while rainwater use is extensive, most systems serve individual households of only a few persons. Residents experiencing sporadic gastrointestinal illnesses are less likely to seek medical attention unless the illnesses are severe and/or life threatening. Contaminated rainwater is also more likely to be a source of sporadic disease episodes because of possible immunity in a proportion of those exposed, together with asymptomatic infection in others (Simmons et al. 2001b). Visitors or persons who have not consumed roof-collected rainwater previously could be especially at risk from waterborne diseases if the water supply is contaminated with pathogenic organisms.

In recently published systematic review of evidence regarding the consumption of roof water and health, Dean and Hunter (2012) found that when compared with unimproved sources, roof water consumption was associated with fewer episodes of diarrheal disease. However, the authors point out that their findings are based on very few studies of variable quality and design and as such further research is needed for conclusions to be drawn with greater confidence. Furthermore they report that the small number of outbreaks that they identified most likely represents under-reporting of outbreaks. As reported by Hunter et al. (2001) small outbreaks may involve just a few people and not be detected against the background level of endemic disease.

In South Australia 42% of residents mostly drink rainwater in preference to their mains water without any apparent effect on the incidence of gastrointestinal illness (Heyworth et al. 1998). To investigate the relationship between tank rainwater consumption and gastroenteritis in South Australia, a prevalence survey of 9,500 four year-old children was undertaken and this was followed up with a longitudinal cohort study of gastroenteritis among 1000 four to six-year-old children, selected on the basis of their tank rainwater consumption (Heyworth et al 2006). Although this study found that children drinking tank rainwater were not at a greater risk of gastroenteritis than children drinking public mains water the study had an important limitation in that the majority of the children had drunk tank rainwater for at least one year. Hence an alternative explanation to there being no increased risk associated with tank rainwater was that the children were exposed to potentially low levels of contaminants and may have developed immunity to some organisms. Furthermore it should be noted that no microbial water quality monitoring was done in this study and that 77% of roof catchments were reported to be free of overhanging trees and 65% of gutters had been cleaned in the last year during the study period.

In a double-blinded, randomized controlled study of water treatment filters and gastroenteritis incidence among 300 households in Adelaide, Rodrigo et al. (2010) reported that the consumption of untreated rainwater does not contribute appreciably to community gastroenteritis. However, as the authors point out their findings may not be applicable to susceptible and immune-compromised persons, young children, or the elderly because these groups were specifically excluded from their study. A limitation of this study is the fact because a number of household participants in both groups may well have had partial immunity to low levels of organisms, visitors (who did not drink the water regularly) should perhaps also have been included in the study. A further
limitation of study was the lack of an alternative water source control group since all the participants used rainwater. Also of concern is the reported high dropout rate (31%) of participants because this may have contributed to the underestimation of the true incidence of gastroenteritis. While the authors state that they conducted limited water quality testing on rainwater tank samples it would have been useful to see if there was any correlation between the E.coli levels and the episodes of gastroenteritis and their severity.

While there are many confounding factors associated with rainwater consumption, there is no question that contaminated tank rainwater increases the risk for acquiring gastrointestinal illness. New Zealand studies have shown that consumption of roof-collected rainwater is associated with a threefold greater risk of campylobacteriosis than that of non-consumers (Eberhart-Phillips et al. 1997). In a case-control study on risk factors for giardiasis among children in Auckland it was found that consumption of roof-collected rainwater significantly increased the risk for this infection (Hoque et al. 2003). A study on salmonella infections in Tasmania found that 81% of the cases had consumed untreated tank rainwater (Ashbolt and Kirk 2006).

Ahmed et al. (2009) used Quantitative Microbial Risk Assessment (QMRA) analysis to quantify the risk of infection associated with the exposure to pathogens from potable and non-potable uses of roof-harvested rainwater in South East Queensland (SEQ). A total of 84 rainwater samples were analysed for the presence of faecal indicators (using culture based methods) and zoonotic bacterial and protozoan pathogens using binary and quantitative PCR (qPCR). The concentrations of Salmonella invA, and Giardia lamblia -giradin genes ranged from 65-380 genomic units/1000 ml and 9-57 genomic units/1000 ml of water, respectively. After converting gene copies to cell/cyst number, the risk of infection from G. lamblia and Salmonella spp. associated with the use of rainwater for bi-weekly garden hosing was calculated to be below the threshold value of 1 extra infection per 10,000 persons per year. However, the estimated risk of infection from drinking the rainwater daily was 44-250 (for G.lamblia) and 85-520 (for Salmonella spp.) infections per 10,000 persons per year. Since this health risk seems higher than that expected from the reported incidences of gastroenteritis, the authors point out that one critical assumption in this study was that the proportion of gene copies represented both viable and infective organisms because qPCR does not provide information regarding viability or infectivity.

Conclusion
Unfortunately public health surveillance data do not reflect the true rate of waterborne illnesses in the community because they usually only capture case-patients in contact with a health care facility. Less than a third of people who become ill from contaminated water are in fact reported because as mentioned above, persons experiencing sporadic gastrointestinal illnesses will only seek medical attention if the illnesses are severe and/or life-threatening (Wheeler et al. 1999). For the illness to be recorded, the ill person must go to a doctor who will examine the person and then collect appropriate samples for a microbiological analysis. Only if the results are positive will they be recorded in the statistics. Lake, Adlam and Perera (2007) have in a large study shown that for every 219 cases of acute gastrointestinal infections in the community only 1 is actually picked up by surveillance systems.
Health scientists are now in broad agreement that outbreaks form only a minor part of the total drinking-water related illness burden and that a large proportion, and probably the vast majority, of the waterborne disease burden arises outside of detected outbreaks. This contrasts with the view, still periodically heard, that the failure to detect outbreaks of waterborne disease means that contaminated water is not a cause for concern (Hunter et al. 2003).

Because of the many benefits roof water harvesting should unquestionably be encouraged for both urban and rural environments since rainwater tanks are a visible and high profile method of conserving water and can be used to reinforce and promote water conservation policies and practices. However, there must be an awareness among the general public, local authorities, and regional public health services about the health risks associated with contaminated roof water. Providing the roof-collected rainwater is clear, has little taste or smell and is collected from a well-maintained system, it is probably safe and unlikely to cause any illness in most users. The health risks of roof-collected rainwater can be minimised by sensible preventative management procedures. Some of the preventative measures are associated with design and installation while others are associated with ongoing maintenance. Well-designed systems are low maintenance and will generally prevent problems occurring so that corrective action to restore safe rainwater quality will be needed infrequently.

References:


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