

Rainwater Quality and Health Issues

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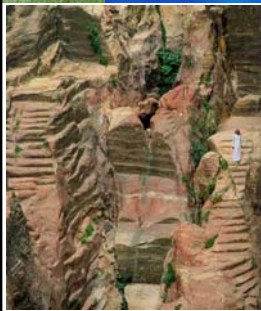
Rainwater Harvesting -
“an old solution to new water supply problems”

UV Disinfection -
“a new problem for old water supply solutions”



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Rainwater quality in context



- Untreated rainwater is used for drinking by millions of people worldwide including 3 million people in Australia
- Untreated rainwater used to be used for drinking in the UK up to start of 20th Century
- In the UK now we recommend untreated rainwater for non potable purposes only



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UV disinfection

- Has an ongoing environmental and economic cost. Unit has to be on 24 hours a day 365 days a year.
- Requires 263kWh electricity a year in commercial situations, 483kWh/year in industrial situations
- Using UV to treat rainwater may lead to a greater carbon load than using mains water. (0.6kWh per m³)
- UV lamps contain mercury and must be changed once every 6-12 months.
- Specifying UV does not compensate for bad initial design



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Risk factors

- Rainwater is classified as fluid category 5 as bacterial contamination is seen as a concern
- Can pathogenic bacteria enter the rainwater supply?
- Do pathogenic bacteria survive and proliferate in water and aerobic biofilms, i.e. in the tank?
- Does rainwater cause a risk at its end use?



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Risk assessment

- Identify the hazards. Decide who might be harmed and how. Evaluate the risks and decide on precautions
- The law requires you to do everything that is “reasonably practicable” to protect people from harm and to “take into account the number of people that could be involved”.
- The difficulties of testing and monitoring systems means that a precautionary approach should be taken where risks are minimised in design
- The easiest way is to compare what you are doing with good practice



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Some good practice guidance

- WRAS guidance note on Reclaimed Water Systems states designates rainwater for WC flush, vehicle wash and hand held hose as Class B *which is not a potable water requirement* (1999)
- CIRIA C539 Rainwater and greywater use in buildings states that for toilet flushing "disinfection is not necessary where a well designed and operated system is installed..... Disinfection should be installed as a precautionary measure *where these criteria cannot be achieved consistently.*" (2001)
- CIRIA C626 Model agreements for sustainable water management systems the recommendation for multi user systems is "settlement and coarse filtration (plus disinfection to achieve total coliforms ,1000cfu/100 ml *if thought necessary*)" (2004)



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Can pathogenic bacteria enter the rainwater supply?



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Relevant bacteria

- *E.coli*. A common intestinal bacteria found in large concentrations within warm blooded animals. Some strains are pathogenic. Transmission route is via faeces from domesticated animals. Do not collect off roof areas where animals can access
- *Salmonella*. From the faeces of birds and small mammals therefore likely to be on roofs. Survival in water and biofilms is low. Can cause gastrointestinal diarrhoea if ingested
- *Legionella*. An opportunistic pathogen that can be found in all types of water. There is no evidence it is more likely to occur in rainwater systems than potable water supply networks. Can survive in biofilms. Transmission route is aerosol inhalation



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Collection areas

- Collecting from roof areas only generally leads to a better quality of water. Exposure to UV, heat and desiccation on the rooftop destroys many bacteria
- Buildings with green roofs may lead to an increase in nutrients and therefore bacteria proliferation in storage tanks.
- Research is currently being carried out on behalf of Formpave to quantify whether there is likely to be pathogen proliferation in rainwater collected from permeable paving



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Route into tank. Pre-filtration is vital

- As most pathogens are bound to particles filtration before storage removes most of the pathogens and most of the organic matter
- Pre-filtration to 1250 microns (1.25mm) maximum should preclude UV disinfection
- A sump pre storage and filtering after storage is not good practice. Organic matter can enter the tank, the filter can become a breeding ground for bacteria



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Do pathogenic bacteria survive and proliferate in water and aerobic biofilms?



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Underground storage 1

- Is an environment that is not conducive to pathogen survival and multiplication
- Average temperatures of below 20 degrees C mean bacteria do not multiply
- Dark conditions means algae does not proliferate
- Protection from sewage contamination means no bacteria and no nutrients
- Metabolic processes within the naturally occurring biofilm utilise nitrates and entrap bacteria
- Oxygenated water enters the tank as it rains

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Underground storage 2

- Krampitz and Hollander tested salmonella enteritidis, Yersinia enterocolitica and Campylobacter jejuni in a rainwater storage tank and found none were able to grow even at temperatures of 37 degrees C (the highest tested). Pigeon faeces were added to raise nutrient levels. Die off was reduced but even with increased nutrient levels and optimum water temperatures the levels of enteropathogenic bacteria did not increase
- Vieweg and Sohn found that the increase in bacteria as a result of fresh inflow is equivalent to the amount of bacteria that die off

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Storage in header cisterns

- Increasingly being specified in the UK
- Little research has been done under these conditions
- Cistern should be insulated against heat loss and heat *gain*
- *Legionella* proliferation more of a concern as growth of legionella occurs between 25-45 degrees C with likely sites being aquatic biofilms.
- Nutrient levels in header cisterns will be as low as in underground storage conditions, therefore conditions are similar to a header cistern fed by mains water.

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Does rainwater cause a risk at its end use?

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End use of rainwater

- In the UK untreated rainwater is used for non potable and non bathing purposes
- Accidental ingestion of rainwater is highly unlikely from WC cisterns or WC pans
- Aerosol formation is not a high risk factor when flushing WCs

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Exposure by toilet use 1

- Gerba et al (1975) found that the probability of a coliform cell reaching the rim of the toilet seat from the siphon by toilet flushing is in the order of 10^{-6} or 10^{-8} .
- Weidenmann and Lucke could detect no CFU on exposed petri dishes placed 800mm above the seat level. At a height of 1200mm a maximum of 9 CFU per 40l of air streaming through a collector was found, even after turbulence and aerosol formation during toilet flushing were enhanced
- Lucke further found that the probability of a single bacteria reaching the vicinity of the human mouth during the flushing action when he mixed rw injected with 10,000 E.coli per litre into a WC bowl containing several billion fecal bacteria to be 1;1,000,000

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Exposure by toilet use 2

- Droplets formed during toilet flushing will frequently contain large numbers of faecal organisms and only a few will be harmful. For reclaimed water to add to the burden of exposure, the faecal coliform content would need to be in excess of 10,000 per 100 ml
- The water in a toilet bowl flushed with drinking water has been observed to hold as many as 10⁸ coliforms



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A sensible standard for RW for non potable purposes

- Bathing Water Quality. EC Directive <10,000 counts per 100ml for total coliforms and <2000 counts per 100ml for faecal coliforms
- Cistern water, unlike bathing water only rarely comes into direct contact with the skin and is less likely to be swallowed
- Should be set for WC flushing, washing machine use and grounds watering in private and public buildings



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Design considerations

- Good design is paramount
- Ensure an expert overview of drainage design and that only roof catchment areas are used
- Integrity of stored rainwater must be maintained. Systems connected to foul water drains must have an anti surcharge valve fitted
- Automatic mains back up supply with no possible cross contamination into mains is essential. Must be a type AA air gap or conform to EN 1717
- All supply pipework must be identified as not potable and all taps marked as NOT DRINKING WATER
- Ensure design is followed correctly during installation
- Ensure a maintenance regime is implemented and followed



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Relevant documentation 1

- The Rainwater Technology Handbook Klaus Konig (2001)
- WRAS Information and Guidance Notes available from www.wras.co.uk (1999)
- CIBSE guide: Reclaimed Water (2005)
- Rainwater and greywater use in buildings. CIRIA best practice guidance C539 (2001)
- Rainwater and greywater use in buildings – decision-making for water conservation CIRIA Project report 80 (2001)
- Model agreements for sustainable water management systems CIRIA C626 (2004)
- Rainwater and Greywater in Buildings BSRIA TN 7/2001
- BSRIA guide: TN6/2002 Water Reclamation guidance



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Relevant documentation 2

- Process Water of Potable Quality: Sense or Nonsense Dr. F K Lucke 1999
- Thermal destruction analyses of water related pathogens at domestic hot water system temperatures. Spinks et al 2003
- An overview of a decade of research into the quality of rainwater supplies collected from roofs. Coombs et al 2005
- Consumption of tank rainwater and influence of recent rainfall on the risk of gastroenteritis among young children in rural South Australia. Heyworth and Rouse 2005
- Water quality treatment processes in Domestic rainwater Harvesting Systems. Spinks et al 2003
- Water quality treatment processes in domestic rainwater harvesting systems. Spinks et al 2003



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Solutions from ech2o

- Identification of best water efficiency solutions and CSH solutions.
- Feasibility studies and design guidance for rainwater or greywater (new build or retrofit).
- Identification of most effective SUDS solutions for existing buildings including green roofs.
- Water audits of existing buildings – residential, commercial, educational and public.
- Work with stakeholders to change behaviour around water use.



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The South East is Under Water Stress

Use Water Sparingly

SEEDA

"Saving water in the Regolith basin" www.ech2o.co.uk

ech₂o consultants ltd work with local authorities, developers, housing associations, water companies, community groups, architects and engineers, at both a strategic and individual site level, to successfully incorporate sustainable water and low carbon solutions into the built environment. www.ech2o.co.uk

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