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SUSTAINABLE DEVELOPMENT OF WATER RESOURCES, WATER SUPPLY AND ENVIRONMENTAL SANITATION

Health & Hygiene Aspects of Rainwater for Drinking

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The World Health Organization is developing guidance on water safety and health aspects of rainwater harvesting & storage. This will be a scientific contribution to the 'rolling' revision of the WHO Guidelines for Drinking Water Quality. WHO acknowledges the need for a thorough assessment of the health aspects of collected rainwater, as increasing numbers of people and communities worldwide use rainwater for domestic purposes, including for drinking. This paper presents a review of microbiological and chemical issues, relevant to rainwater and health risks. Several concerns are raised that may need further consideration in design, maintenance and research in rainwater use.

The paper is an output of the collaborative programme on water quality management implemented by the World Health Organization with support from the Australian Agency for International Development.

Keywords: rainwater, drinking water, chemical and microbiological quality, water safety plans, health risk assessment

Introduction

Rainwater harvesting for domestic use and as drinking water source, is becoming increasingly popular as the availability of good quality water declines.

Households and communities have augmented or substituted their household supplies with rainwater for reasons of scarcity, salinity, quality of service and for risk substitution (Heijnen, 2001). Rainwater is nowadays used as a source for numerous domestic applications like drinking, bathing, laundry, toilet flushing, hot water supply and for gardening purposes.

The quality of rainwater can vary depending on atmospheric pollution, harvesting method and storage. While the quality of collected rainwater may vary, on the whole, harvested quality is found to be equal to that of the regular treated water supplied through the public mains. A study (Heyworth, 2001) showed that under-fives in rainwater supplied, rural households were at no greater risk to diarrhoea than those who drank the treated piped water of Adelaide.

Rainwater catchment systems are open to environmental hazards because of the nature of the catchment area. There are several ways contaminants can enter the rainwater system and compromise the water quality. For instance, chemical contaminants may dissolve during precipitation and leach due to characteristics of the rainwater system components while microbial risks can be introduced through bird droppings, or poor collection and storage design. A sensible, preventive water quality management practice will thus improve the final water quality in the tank.

Rainwater collection and storage systems need to be monitored in a similar fashion as any other piece of im-

portant infrastructure around the house or the institution. Monitoring of rainwater systems consists of a range of visual inspections of the functionality of the facilities (no leakage or overhanging tree branches), and of the water collected: colour, smell, taste and turbidity.

Water testing is useful in order to ascertain the general condition of water and to evaluate effectiveness of the system maintenance and treatment. Checking for bacterial (Total Coliform, Faecal Coliform, Heterotrophic bacteria) and any chemical contamination (inorganic substances, organic chemicals etc.) of concern can be important.

It is very important that users understand the potential hazards and risks of neglect in rainwater harvesting. Local health authorities often have developed suitable guidance. Nowadays simple maintenance schedules based on water safety plan approaches are being developed to assist householders and institutional users to get a good water quality, consistently.

Contaminant Risks

Consumption of rainwater for drinking is indirectly related to perception of quality, and of course on preference and taste. Most of the rainwater tanks are generally not tested for water quality, therefore householders have no knowledge of true water quality, rather only a perception of water quality. In general the quality of rainwater is considered at household level by the -

- Presence of leaves and other material
- Presence of mosquito larvae and other insects, rodents and frogs
- Colour and taste

Chemical Contaminants

While rainwater is considered pure, there are a large number of man-made atmospheric pollutants such as sulphur dioxide, nitrogen oxides and various hydrocarbons, which together are the principal causes of acid rain. Such water can be unsafe to drink, especially in areas of heavy pollution such as industrialized urban areas. Although most serious contaminants are normally limited to urban and industrial locations, pollutants can be transported over great distances before being washed out in the rain. (Gould and Nissen-Petersen, 1999.)

Rainwater Catchment System Components

The type and condition of the roofing material is known to affect the water quality (Fujioka, 2002). Paint coatings on roofing may oxidize through weathering. When broken down, these can be washed into the rainwater tank. Roofs painted with lead based paints and lead and copper materials used may result in unacceptable concentration of heavy metals in rainwater supply. Chimneys which are present on the roof can emit hydrocarbons, such as phenanthrene (Kennedy et al., 2001) which may affect health.

The water storage system can also impact the quality of water. When cement and ferrocement tanks are new they can increase the alkalinity of the stored water, and also the calcium content. These effects have not been known to be hazardous to human health (Gould-Petersen, 1999). Conversely, a low pH of collected rainwater does not pose a threat to health, but may increase the rate of dissolution of metal tanks, pipes and fittings.

New tanks tend to have a problem with odour and taste due to the leaching of coatings. Flushing the tank before use can reduce any lingering taste and odour.

Microbiological Quality

Tank rainwater is usually harvested from a roof catchment area. This catchment area is open to the environment and can be accessed by birds, insects and animals. Faecal droppings from birds, lizards, mice, rats and possums, which can access the roof catchment, may contain pathogenic microorganisms which are harmful to health when ingested. Frogs may reside or visit the rainwater tank (Lye, 1992). Thermotolerant coliforms and E. Coli have been commonly identified in domestic tanks.

Microorganisms that are washed into the tank may be present in the water column, or in the sediment if attached to particles that settle to the bottom of the tank. Microorganisms found to be carried by birds and animal vectors include, *Cryptosporidium*, *Giardia*, *Campylobacter* and *Salmonella* spp. Each of these microorganisms is known to cause gastroenteritis.

Although not all species of the microorganisms harboured by various animals are known human pathogens, they are still a potential risk to humans. The most common carriers are birds. They can easily access the rainwater catchment area and contaminate it through defecation. While not conclusive, one of the studies (Simmons et al., 2001) reported

- following an outbreak investigation in New Zealand – that ‘the high prevalence of bacterial indicator organisms, coupled with the identification of *Salmonella* and *Cryptosporidium* suggests that roof-collected rainwater supplies represent a potential source of human illness’.

Air-Borne Micro-organisms

Previous literature reports on roof water quality have given little consideration to the relative significance of airborne micro-organisms. Analysis of direct roof run-off at an urban housing development in Newcastle, on the east coast of Australia indicated that airborne micro-organisms represented a significant contribution to the bacterial load of roof water at this site, and that the overall contaminant load was influenced by wind velocities, while the profile (composition) of the load varied with wind direction. (Evans et al., 2006)

Minimizing Contaminant Risks

As rainwater collects impurities and contaminants while flowing over the collection area, it is good practice to have a first flush removal mechanism included in the system. After a dry period, dirt and bird droppings may seriously compromise the quality of the water collected.

Recent work by the Development Technology Unit of the University of Warwick (Martinson, 2005) suggests that for each mm of first flush the contaminate load will halve. Further work is underway to see what practical implications this may have in system management.

The use of inlet filters provides another way to separate dirt from good rainwater. In order not to waste precious rainwater, inlet filters should have capacity to handle larger amounts of water and should therefore preferably be self-cleaning. Clever inlet filters are nowadays commercially available in industrialized countries that are promoting rainwater harvesting.

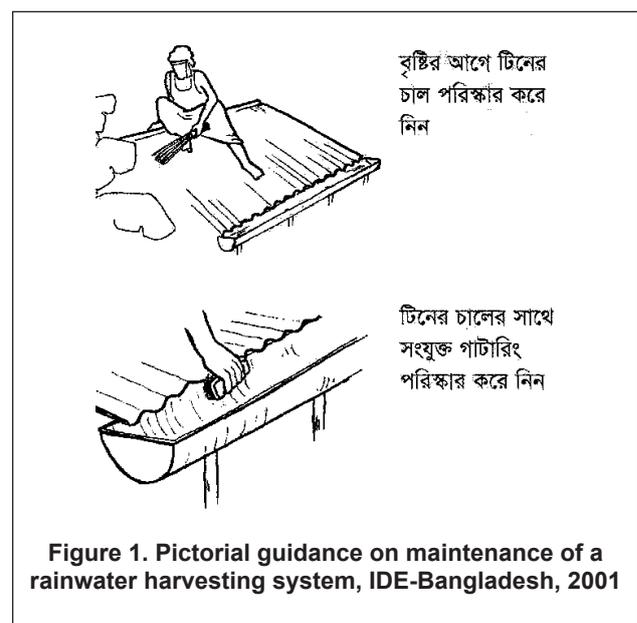


Figure 1. Pictorial guidance on maintenance of a rainwater harvesting system, IDE-Bangladesh, 2001

During storage, and depending on the time after the last rainfall, bacterial die-off can be substantial, with a log-reduction achieved in one or two weeks. Bio-films developing at the tank-water interface are also considered to have a positive effect on the water quality (Coombes et al., 2005).

Mosquito Breeding

Apart from the chemical and microbiological problems there is also a concern of vector breeding in the gutters and cisterns used for storing the harvested rainwater. The major risk is that of mosquito breeding, although rats, lizards and some other small animals do sometimes enter the water (Vasudevan et al, 2001). The World Health Organization (WHO) recommends that all tanks have screens or similar devices to prevent adult mosquitoes from emerging (WHO, 1997).

Good Practice for collection of Harvested Rainwater for domestic and potable purposes

The interest in Rain Water Harvesting is growing around the world. While in Australia and New Zealand, in the Pacific Islands and South Asia, and in South America, rainwater is often also a drinking water source, in parts of the USA and in Western Europe, rainwater is increasingly used for a one-time domestic purpose before it is being discharged. The common interest is leading to policy statements, legal provisions and guidance being developed and updated in several countries.

Recently the European Commission also issued its recommendation for Using Rainwater in Public and Private Buildings (EC, 1990-1994). This interest is helpful as it will increase the attention and the funds that will go into practical research.

Rainwater systems in Germany have become quite sophisticated with a lot of attention given to retaining a good quality water, even though the water will only be used for flushing the toilet, watering gardens, supplying washing machines, make-up feed for cooling water etc. This interest has led to a good number of solutions for inlet filters, storage and use that make it easier to manage one's rainwater.

In several countries in Asia, e.g. Sri Lanka, suitable guttering and storage tanks have become available. This helps

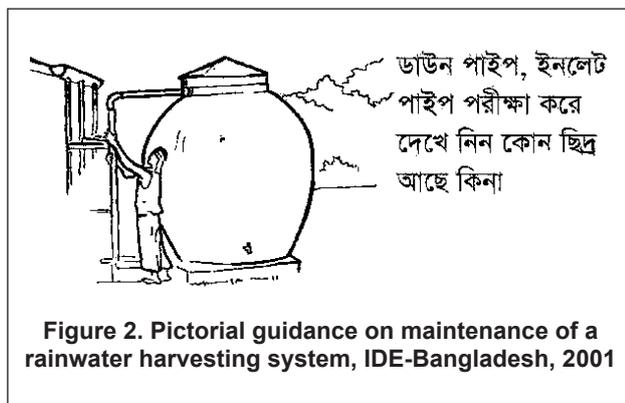


Figure 2. Pictorial guidance on maintenance of a rainwater harvesting system, IDE-Bangladesh, 2001

in making rainwater collection and storage accessible to larger numbers of households. Simultaneously it requires that a rainwater harvesting culture starts to be developed that highlights good practice, in order to retain the quality of water. In the rush to promote rainwater harvesting several government and non-governmental agencies have supported households, often through subsidy, to install a facility, but have not given adequate attention to the detail of the systems to ensure good quantitative collection and safe qualitative storage. In some areas in South Asia it has deplorably led to low numbers of tanks being in use effectively.

When undertaking a rainwater harvesting programme, it is worthwhile to invest in clear descriptive designs, train local artisans and make sure there is good supervision, and a final check of the system is done together with the householder. Poor technical support may jeopardize the institutionalization of a rainwater culture in an area. That may be a pity as conservation of rainwater may well prove an important contribution to local water resources management and to a better quality of service in water security to the household.

Water Safety Plans

The 3rd WHO Guidelines for Drinking Water Guidelines promote the application of risk assessment and water safety plans. In Bangladesh and the Maldives such water safety plans have been drafted and are used as household and community system tools for proper maintenance. Regular cleaning of roof and guttering and surrounding will reduce contamination risks. Cleaning of the tank every year (at the end of the dry season) will help maintain good quality water.

Water Quality Testing and Treatment of rain water

Ideally water quality testing (chemical or microbiological) of domestic rainwater tanks should be done regularly, to verify its suitability for drinking. Testing of the microbiological quality also confirms the effectiveness of the protection /water safety plan processes used.

To make regular testing viable, there is a need to further validate cost effective test kits/methods for assessing microbial quality (H_2S strips?) for use at household level. Also, further work needs to go in developing microbiological indicators more suited to assessing microbial quality of rainwater.

As rainwater may have low levels of microbial contaminants, it is advisable to ensure the safety of the water through sedimentation, filtration, chlorination, boiling, SODIS etc.

Epidemiological Evidence/Outbreaks

There have been few reports of illness associated with the use of rainwater. This may well be because in many instances illness may not be associated with consumption of rainwater. In small island communities rainwater is often an important, if not the only, source of drinking water. Analysis of public health data of such communities may inform about public

health risks of rainwater. There is a need to link water quality and public health data to better understand risks, if any. This is not easy as demonstrated by a study in the Virgin Islands where *Cryptosporidium* and *Giardia* was detected in a large number of rainwater cisterns, but where the public health significance of this occurrence was not established. (Crabtree et al., 1996).

Epidemiological studies on rainwater systems are relatively uncommon because outbreaks tend to involve few individuals, and illness is often isolated at individual catchment systems.

Conclusion

Generally, the physico-chemical quality of rainwater in terms of colour, odour and taste, pH, total dissolved solids (TDS) and total hardness (TH), meets the prescribed standards. Toxic metal ions and toxic chemicals are reported only in some cases and may arise from material used for the roof, atmospheric pollutants adsorbed on dust, industrial and urban traffic emissions and pesticides-agricultural pollution. Generally, serious chemical contamination of stored rainwater is rare.

Investigations have revealed that in many instances stored rainwater did not meet WHO, EPA or other similar standards with respect to one or more bacteriological water quality indicators and thus direct consumption of untreated rainwater could pose a risk to human health. Rainwater can best be made safe for drinking through filtration, chlorination, boiling, SODIS etc.

For most households, a regular check on system functionality and hazard identification, using a water safety plan type of record, and the guidance provided by many local public authorities, will help achieve good quality water.

References

- Coombes P.J., Dunstan R. H, Spinks A, Evan C A, Harrison T, (2005) "An overview of a decade of research into the quality of rainwater supplies collected from roofs", *Proceedings of 12th International Conference on Rain Water Catchment Systems*, New Delhi, India.
- Crabtree, K, Ruskin R, Shaw S and Rose J .(1996) "The detection of *Cryptosporidium* oocysts and *Giardia* cysts in cistern water in the U.S. Virgin Islands", *Water Res*, 1996; 30(1): pp 208-216.
- Evans C A, Coombes P.J., Dunstan R. H. (2006) "Wind, rain and bacteria: The effect of weather on the microbial composition of roof-harvested rainwater". *Water Res*. 2006 Jan; 40(1):37-44. Epub 2005 Dec 15.
- Fujioka, R. (2002) "Rainwater roof catchment systems, microbial quality of", *Encyclopedia of Environmental Microbiology*, vol. 5, pp. 2674-2685.
- Gould, J and Erik Nissen-Petersen. (1999) *Rainwater catchment systems for domestic supply: Design, construction and implementation*. ITDG publication, ISBN 1 85339 456 4
- Heijnen H. (2001) "Towards water quality guidance for collected rainwater" *Proceedings of the 10th International conference on rainwater catchment systems.*, Mannheim, Germany, pp 133-140.
- Heyworth J. (2001) "A diary of gastroenteritis and tank rainwater consumption in young children in South Australia" *Proceedings of the 10th International conference on rainwater catchment systems*. Mannheim, Germany. pp 141-148.
- Kennedy, P, Gadd, J. & Mitchell, K. (2001) "*Preliminary examination of the nature of urban roof runoff in New Zealand*", Ministry of Transport, Te Manatu Waka.
- Lye, D. (1992) "Microbiology of rainwater cistern systems: A review", *Journal of Environmental Science and Health*, vol. 27, no. 8, pp. 2123-2166.
- Martinson, D. B., & Thomas, T. H., (2005) "Quantifying the first flush phenomenon", *Proceedings of 12th International Conference on Rain Water Catchment Systems*, New Delhi, India.
- EC (1990-1994) Recommendations for using rainwater in public and private buildings (European Commission, Directorate General for Energy XVII).
- Simmons G., Hope V., Lewis G., Whitmore J and Gao W. (2001) "Contamination of potable roof-collected rainwater in Auckland, New Zealand", *Water Research* Vol. 35, No. 6, pp 1518-1524.
- Vasudevan P., Pathak N., Chauhan P.& Mittal P.K. (2001) "*DRWH design & insect breeding*", Milestone Report C4 (EU Project), DRWH Design & Insect Breeding, <http://www.eng.warwick.ac.uk/dtu/pubs/rwh.html>
- World Health Organisation (1997) "*Guidelines for drinking-water quality*", Second Edition-Volume 3: Surveillance and control of community supplies. WHO, Geneva,.

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