Household water security – the quality component

Andrew Trevett

Providing a safe water supply is not enough if water becomes contaminated on the way home. A study from Honduras reveals the various points where contamination occurred between the borehole or well and the drinking cup.

The e-mail conference on household water security last October (see the Resources Guide in this issue of *Waterlines*) provided a forum to discuss one of the most fundamental issues for millions of people throughout the world. An early point of discussion centred on the definition of household water security. The World Health Organization (WHO) views the concept as '…the reliable availability of safe water in the home for all domestic purposes'.[1] Conference participants added or expanded on this definition to encompass links with food security and livelihoods, shrinking freshwater resources, and in terms of society struggling with different priorities. Such breadth of definition is indicative of the interrelationship between the distinct components of water resource management. It also serves to illustrate how we tend to interpret such concepts on the basis of our own experience and professional perspective. I for one interpreted the conference title theme as announcing an in-depth debate on household drinking water quality. This no doubt is because we have recently completed an in-depth study on the subject at the Institute of Water and Environment, Cranfield University. Specifically, the research investigated the potential for water quality to deteriorate between the points of collection and consumption in rural Honduran communities.

Research background

A direct consequence of the insufficient resources allocated to providing access to safe water supply is that a minimum service level must often be shared by the entire community. This might be a borehole fitted with a hand-pump, or public standpipes in the case of piped supplies which may not even provide a 24-hour service. This requires that water must be collected and transported to the home and stored for later use. Although the quality of water supplied may be excellent, there is an obvious risk of it becoming re-contaminated where it is subject to less than ideal hygiene conditions or handling. This problem was identified as a health risk more than 40 years ago in Wagner and Lanoix's classic text[2] yet relatively little interest has been shown since then. If water-quality deterioration is a common and widespread phenomenon, then the expected health benefits from the provision of safe drinking water might be undermined. Our research project was designed to investigate:

- the magnitude and main causes of water-quality deterioration
- the health risks of consuming re-contaminated drinking water
- appropriate interventions that would minimize deterioration.

Water-quality deterioration

Field research took place in three rural villages in Honduras between July 1998 and December 2000. The water supply in two of the villages came from protected hand-dug wells, while the third village had a borehole. All of the wells were fitted with hand-pumps. Water samples from the wells and household storage containers used for drinking water were analysed for thermotolerant coliforms (ThC) as an indicator of faecal pollution. Table 1 shows the mean bacteriological water quality measured at source and in the household storage container. Deterioration occurred regularly and frequently, and was experienced by the majority of the 55 study households. It can be seen that household stored water originating from the borehole is of significantly better quality than that drawn from hand-dug wells. This suggests that the magnitude of deterioration between the points of supply and consumption is a function of the water quality at source.

Having established a database of water quality, we then set out to investigate the main factors leading to recontamination. This second phase of the research consisted of a detailed observational study of household water management and a series of field-based experiments. We had already observed that the women collected water in a variety of containers including buckets and jerrycans, and then transferred the water to a storage container. The preferred storage container in the majority of homes is the *tinaja*, which is made of fired clay and characterized by a wide neck. A series of hypotheses were drawn up which focused on how and where deterioration was occurring. We considered whether particular collection or storage practices were influencing water quality, what aspects of hygiene

Table 1 Mean (geometric) thermotolerant coliforms/100ml in water samples measured at source and in household storage containers

Type of well	Water quality at source (sample size)	Water quality in household storage container (sample size)
Hand-dug well	111 (108)	202 (334)*
Borehole	1 (72)	72 (238)**

*statistically significant at the 0.05 level of probability
**statistically significant at the 0.01 level of probability

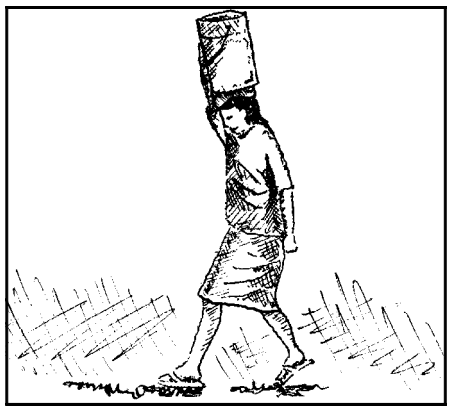

Figure 1 Air-borne contamination seems to have been insignificant
Credit: Sam Warby

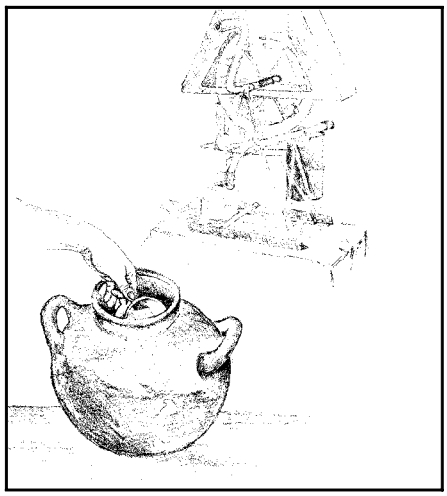

Figure 2 Serving water using a ladle or cup introduced more contamination than pouring directly
Credit: Sam Warby

behaviour were most important, and whether the storage containers themselves were more or less vulnerable to recontamination.

Summarizing our findings briefly, on many occasions water became grossly contaminated during collection. The containers were usually rinsed and wiped with the hand before filling, and often a hand was used to scoop out water from an overfull bucket. This suggests that dirty hands or collection containers or both were causing the initial deterioration in water quality. Most collection containers were not covered and during the journey home they would have been exposed to any airborne contaminants. Probably of more importance was hand–water contact that was observed as the women lifted the containers on to their heads and occasionally when steadying the container while walking. When the

Figure 3 Straining the water through a cloth probably introduced contamination
Credit: Sam Warby

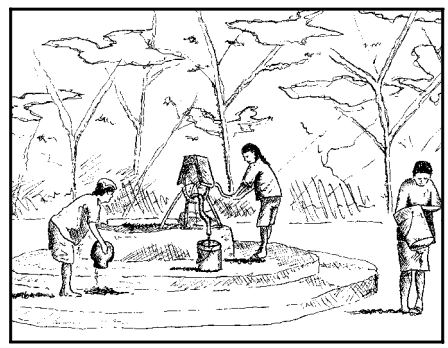

Figure 4 Dirty hands or buckets may cause the initial deterioration in quality
Credit: Sam Warby

water was transferred to the storage container it was usually 'filtered' through a cloth. No sediment or floating matter was apparent and it was learned that this practice dated from the time when the women collected their water from the river. However, the practice of filtering did represent another potential source of microbial contamination.

The wide-necked *tinajas* were usually found to be covered. However, when water quality in covered and uncovered containers was compared, no statistically significant difference in stored water quality resulted from covering the container. This is noteworthy given that the recommendation to cover the storage container is a common feature in hygiene promotion programmes. However, a comparison of different serving methods revealed that stored water quality in households that poured water exhibited much less contamination than in those using a ladle or cup to serve their drinking water (Table 2).

The observational study confirmed that hand–water contact occurred frequently during the serving of drinking water. It was also noted that a high proportion of children served themselves or siblings with drinking water, some as young as two years old. The hands of such young children may be expected to be more contaminated with faecal material than an adult's. Although we did not examine children's hands for faecal contamination, we did carry out such a test on women householder's fingertips. It was found that faecal contamination was present on 44 per cent of fingertips tested during normal household activities, and this faecal material was easily transferred to water. Furthermore, faecal material was also detected on cups and beakers used for serving stored drinking water.

A significant health risk?

It is widely accepted that drinking water containing pathogens derived from human, or in some cases animal excreta, represents a health risk. However, VanDerslice and Briscoe (1993)[3] suggest that drinking water that becomes re-contaminated in the home does not represent a serious risk of diarrhoeal disease. They argue that household members are likely to develop immunity to pathogens that are spread to other family members as a result of poor hygiene in the home. Since the pathogens in household stored water are likely to originate from the faeces of household members, further exposure to these 'internal' pathogens would not increase the risk of diarrhoea.

It is certainly true that acquired immunity is the result of exposure to a previously unseen 'pathogen'. However, when an infant's immune system is still developing it is entirely possible that an infection becomes established before the immune system is fully primed and can prevent the development of a disease. Furthermore, if an

Table 2 Mean (geometric) thermotolerant coliforms/100ml in stored drinking water compared by serving method (data is from the community with a borehole)

Serving method	Geometric mean ThC/100ml (number of samples)
Dip (cup or beaker)	86 (74)
Ladle	182 (77)
Pour	23 (78)

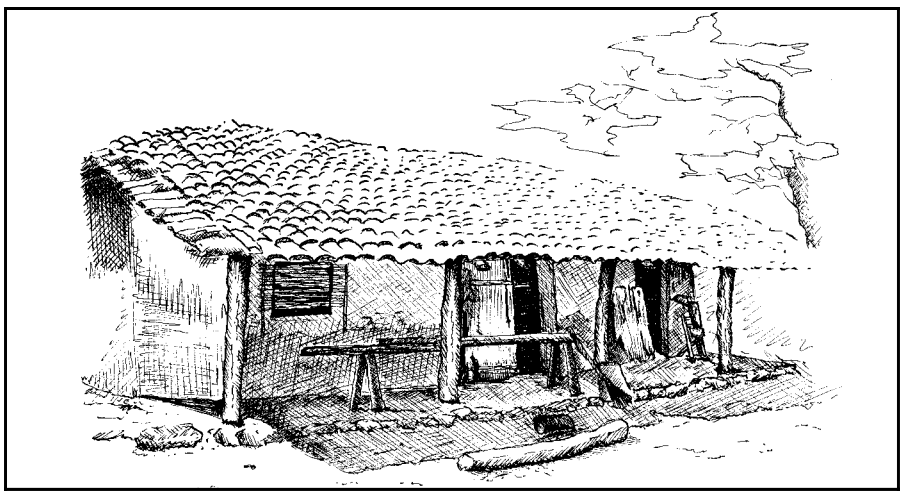

Figure 5 An understanding of existing practices is essential before introducing new management practices
Credit: Sam Warby

infant is malnourished, then the number of organisms needed to cause infection is effectively lowered. Other factors that cause immunodeficiency and are common to children and adults in developing countries are HIV and helminth infection. With regard to the differences between internal and external pathogens, the strength of this argument depends very much on the extent of interaction between family members and the external community. It is not difficult to think of examples of social interaction where external pathogens could easily be introduced into the household and perhaps transmitted through stored drinking water. Studies of cholera transmission identified recontaminated drinking water as a probable transmission mechanism in Peru and India, suggesting that the disease was introduced into the household by a family member.[4,5]

Appropriate interventions

Appropriate interventions are clearly necessary in order to prevent or minimize water-quality deterioration, and so maximize the health benefits from improved water supply. Physical measures such as specially designed water storage containers, and educational interventions that promote good hygiene behaviour have great potential in ensuring safe drinking water is maintained during collection and storage. World Health Organization guidelines recommend that storage containers be designed to reduce the risk of contamination and have the following characteristics:[6]

- have a secure, tight-fitting lid
- able to withstand rough handling without cracking
- easy to lift from the ground and carry back to the storage point after filling
- easy to fill and clean, so that contact with hands in minimized.

Nevertheless, if hygiene behaviour is less than perfect it is unlikely that even a well-designed storage container can prevent recontamination. Special containers on their own may not be able to completely prevent the deterioration of water quality. Either it is accepted that some deterioration of water quality will occur, or alternatively a method of household water treatment must be considered. Several promising methods have been tested including point-of-use disinfection, locally manufactured ceramic filters (see the Technical Brief in this issue), and solar disinfection (SODIS, see Technical Brief in the last issue). A comprehensive review of household water treatment can be found in the recent WHO publication 'Managing Water in the Home'.[7]

Where it is decided that an intervention should be introduced to minimize water-quality deterioration, it is essential that the typical household water management practices in the target community are observed and understood. A 'text book' intervention that is introduced without having first carried out an appraisal of water management practices runs the risk of being unsustainable or rejected.

Conclusions

Our research in Honduras provides evidence that the recontamination of drinking water is a common and widespread problem in rural villages sharing a communal source. The deterioration occurs as a result of multiple factors linked to hygiene practices and circumstances. Nevertheless, only hands are involved at every stage of domestic water management and can directly contaminate stored drinking water through contact, or indirectly through the transfer of faecal material to utensils used in household water management. Specially designed storage containers or even household-level water treatment will likely minimize deterioration but these interventions must be combined with continued efforts to raise levels of hygiene awareness.

About the author

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