Impact of jerry can disinfection in a camp environment – experiences in an IDP camp in Northern Uganda

Andre Steele, Brian Clarke and Owen Watkins

ABSTRACT

In July 2007, a study by the Centre for Environmental Health Engineering, at the University of Surrey, assessed a modified method of jerry can cleaning in an internally displaced persons (IDP) camp in Kitgum, N. Uganda. The poor condition of drinking water vessels used in the camp was confirmed as a potential source for microbiological contamination both visually and by microbiological testing. Jerry cans were disinfected using high strength sodium hypochlorite (NaOCl) generated using an experimental AquaChlor Solar unit. The study suggested that regular jerry can cleaning, using a high strength chlorine based disinfectant, offers an effective method of alleviating the adverse effects of contamination in water collection and storage vessels. Results indicated that the method is capable of significantly reducing thermo-tolerant coliform numbers to below 5 cfu/100 ml in most cases. Chlorine strength depletion after repetitive cleaning confirms the impact of process. The method does not substitute for good hygiene practices, which are essential for maintaining water quality in the household. It is suggested that the process can play an important role during outbreaks of water-borne diseases, such as cholera, particularly if combined with regular water disinfection.

Key words | disinfection, emergency household water collection and storage, hygiene practices, jerry can cleaning

Andre Steele (corresponding author)
Brian Clarke
Owen Watkins
Centre for Environmental Health Engineering,
School of Engineering,
University of Surrey, Surrey,
UK
E-mail: *a.steele@surrey.ac.uk*

INTRODUCTION

The conflict in Northern Uganda between the Ugandan government and the Lord's Resistance Army (LRA) has lasted for over 20 years (HRW 2005). In 2005 the IDP population was estimated at between 1.6 and 2.0 million people (OCHA 2005). It is a complex emergency, where relief efforts were restricted due to security (Walker 2007) and overcrowded camps suffered from issues with food supply, water availability, hygiene and security. Leading causes of mortality were malaria, diarrhoea, violence and HIV/AIDS. The crude mortality rate (CMR) in the Kitgum region from January to July 2005 was 1.91/10,000/day compared to the Ugandan average of 0.46/10,000/day (Checchi 2006). A cessation of hostilities was signed in August 2006 (Brown 2006) bringing a tentative peace. Today approximately 75% of the population remain in camps. Most of the other 25% have dispersed to temporary satellite settlements which have improved living conditions and greater access to farmland (Murtagh 2007).

Outbreaks of Cholera were confirmed in May of 2006 and again in 2007. As water sources were mainly ground-water and contaminant free, the spread of the disease is believed to have been from social interaction, and poor hygiene. Rapid response from aid agencies in the area included the disinfection of water collection vessels by dosing with Aquatabs; high strength chlorine tablets (Murtagh 2007). Disinfection of collected drinking water during epidemics is an established practice (WHO 2005) and it is known that contamination between collection and point-of-use can be significant (Wright *et al.* 2004). It has been shown that biofilm growth on the inside of containers

doi: 10.2166/wh.2008.072

can act as microbial reservoirs (Jagals *et al.* 2003) and without regular disinfection of drinking water, there is little protection against post-collection contamination build-up. Behavioural change strategies have been shown as effective against disease transmission (Curtis & Cairncross 2003), but is suggested as not suitable for epidemics. Container cleaning with a high-strength chlorine disinfectant has been indicated as an effective means of reducing the incidence of diarrhoeal diseases (Walden *et al.* 2005).

In July 2007, a team from the Centre for Environmental Health Engineering (CEHE), with the support of Oxfam GB, undertook a short study to assess the effectiveness of jerry can cleaning using high strength sodium hypochlorite. The aims of the study included:

- assessment of the effectiveness of jerry can cleaning using a strong disinfectant,
- assessment of the recontamination of jerry cans with use after cleaning.

METHODOLOGY

Generation of disinfectant and storage

High strength sodium hypochlorite (NaOCl) was generated through electrolysis of 3% brine solution using a custom built AquaChlor Solar unit. Developed by Dr. Del Signore of Gaia Richerche, Italy, the unit was donated to CEHE for the duration of this study. The disinfectant was generated on location in Kitgum using local salt and borehole water.

Disinfectant strength

The disinfectant strength was measured as total and free chlorine using the DPD method for the HACH DR/890 handheld colorimeter. The range of detection was 0.00 to 2.00 mg/l. A 1 in 10,000 dilution was used, where necessary. Large quantities of distilled water were not available and bottled water was used as the dilutant. It is acknowledged that there are inherent errors in the dilution process and these are considered in the analysis. The stock disinfectant solution was tested before and after the cleaning of each jerry can. The data presented represents the reduction in total and free chlorine after each cleaning.

Jerry can cleaning

13 households (HH) were approached in the study. Their involvement was entirely voluntary. One jerry can from each household was made available and marked with the household's name. A sample from each jerry can was taken for microbiological testing before cleaning. Two methods of cleaning were used.

Method 1: the empty jerry can was half filled with disinfectant. The opening sealed and the can shaken for 1 minute. The disinfectant solution was decanted back into the stock solution. A sample of the stock solution was taken to determine any reduction in chlorine levels. The jerry can was rinsed and filled from the water source. A second sample was taken for microbiological testing. HH 1 to 9 were tested using this method.

Method 2: the empty jerry can was completely filled with stock solution and allowed to sit for 1 minute (HH 10 & 11) or 5 minutes (HH 12 & 13). The disinfectant solution was decanted back into the stock solution container and a further stock solution sample was taken for testing. The jerry can was rinsed and filled from the water source. A further jerry can sample was then taken for microbiological testing.

Recontamination of jerry cans

The cleaned jerry cans were retested at 3 and 5 days after initial cleaning. Samples were taken from water in the jerry cans. Empty cans were filled with water and allowed to sit for 10 minutes before a sample was taken. Due to time limitations, not all cleaned jerry cans were tested on day 3 and day 5.

Microbiological testing

The jerry cans were tested for thermo-tolerant coliform bacteria, assumed faecal. A Delagua Field Kit was used with the recommended standard procedures. All samples were initially stored in a cool box with ice and tested within 3 hours. Two samples were filtered for each jerry can tested. The coliform count was measured as colony-forming-units per 100 ml (cfu/100 ml).

RESULTS

Okidi satellite settlement

The Okidi settlement is located 20 km west of Kitgum and 30 km north-west of the parent IDP camp Amida. It is a remote settlement with a current population of 4,171. Groundwater is the main water supply and the settlement has three hand pump installations. One lies on the western most edge of the settlement and the other two lie at distances of over 500 m outside the camp. The study was carried out at the first hand pump (Figure 1) as this was the most frequently used allowing easy access to the volunteers. The source consistently tested 0 cfu/100 ml for microbiological contamination, indicating that any contamination in the jerry cans did not come from the water source. Standard 20 litre jerry cans were used with the daily quantity collected per household varying with distance from the water source, family population, source yield and population to source ratio. Water is stored either in the jerry cans or decanted into house-based vessels, the most common being clay pots. Visual observation and microbiological testing of household water storage indicated that the drinking water remains a significant health risk, despite water sources being safe.

Figure 1 | Hand pump in Okidi where the study was undertaken.

Effectiveness of jerry can disinfection

The coliform removal results for jerry can cleaning are presented in Table 1 and indicate that the process can be effective. It was not possible to reduce the coliform count to 0 cfu/100 ml in every case, suggesting that the cleaning process was incomplete. The data does not indicate that any one method of cleaning was more effective than the other. However, cleaning using Method 1 led to more consistently lower coliform counts than Method 2. HH 12 was cleaned using Method 2. It had an initial count of approximately 1000 cfu/100 ml, which was reduced to 90 cfu/100 ml. Considering a chlorine solution concentration of 2750 mg/l was used with a contact time of 5 min, it is suggested that disinfection would have taken place provided contact was made between the disinfectant and the can surface. For practical reasons Method 2 did not allow the complete filling of the can and, hence cleaning may not be complete without agitation. It is possible that the high coliform count resulted from the introduction of contamination prior to cleaning, and was not a direct result of the condition of the can. This would not explain the relatively high coliform count after cleaning.

HH 8 and 10 saw a slight increase in coliform count indicating that recontamination may have occurred after cleaning, before a sample was taken. It was noted that funnels

Table 1 | Faecal coliform contamination of jerry cans before and after cleaning

		Faecal Contamination	
HH	Name	Before (cfu/100 ml)	After (cfu/100 ml)
1	Vicki	2	1
2	Charles	2	0
3	Jessica	375	0
4	Christine*	2	–
5	Christine Aciro	1	0
6	Awena Irine	14	3
7	Lamunu Evarine	9	5
8	Akumu Margrete	5	15
9	Aparo Joska	15	2
10	Labye Betty	0	1
11	Layat Alice	2	0
12	Amaio Alice	1,000	90
13	Aringo Betty	12	0

*This household withdrew from the study after the initial microbiological sample was taken.

were used to minimise water loss during jerry can filling. These were cut from plastic bottles and were invariably discarded between use, creating a potential contamination risk. Similarly, the mouths of the cans were often dirty and this may also have represented a contamination pathway.

Reduction in strength of stock solution

Figure 2 illustrates the reduction in stock strength after each jerry can cleaning for HH 6 to 9. The trend suggests a continuous decrease in strength after each jerry can has been cleaned. The increase in strength after cleaning of HH 6 is attributed to procedural errors introduced by the dilution process. It is suggested that the trend in the data set is consistent with expectations.

Recontamination of jerry cans

The results for jerry can recontamination are presented in Figure 3. They indicate that the process may not prevent recontamination. This is seen by the levels of recontamination in HH 1, 2, 5, 7, 8 and 9. As the process does not result in a free chlorine residual this is a logical finding. If it is considered that the cleaning was effective, it follows that subsequent contamination results from an external source. This is supported by the levels of contamination seen in HH 8. It is deemed improbable that a relatively low coliform count of 15 cfu/100 ml immediately after cleaning will increase to 1000 cfu/100 ml due to a pathogen reservoir within the can.

DISCUSSION

The results indicate that the process is an effective means of cleaning water vessels, but not of preventing recontamination. This supports previous findings suggesting vessel cleaning using chlorine based solutions can play a role in reducing the incidence of diarrhoeal diseases (Walden *et al.* 2005). It is suggested that the use of a high strength chlorine solution is a more successful method than the currently employed cleaning methods. These involve agitation with water, soap, and clean stones (Murtagh 2007). As few people have soap, many carry out cleaning with just stones (Balsamo 2007). Whilst the method employed by Walden *et al.* (2005) also used stones to scour the inner surfaces, this can lead to scratches and grooves in the plastic. Without disinfectant or soap, this could lead to colonisation by microbes and the development of a protected biofilm.

Though the method was generally successful as a cleaning process, the recontamination results point to a lack of emphasis on the protection of drinking water in the household. It has been shown that contamination can easily occur after collection (Clasen & Bastable 2003). In the Okidi community it was observed that water was stored at ground level, often outside the house. This allowed easy access by children and animals, and could have resulted in contamination. This was accentuated by the fact that not one jerry can had a lid. These observed practices indicate that the effectiveness of hygiene promotion in a complex emergency environment needs to be considered. It is suggested that there may be an inevitable gap between the aims of the hygiene promoters and the hygiene practices adopted by the

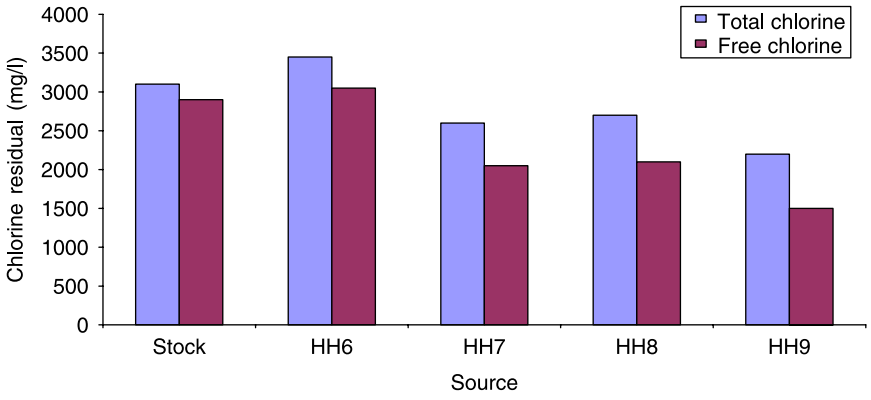

Figure 2 | Reduction of disinfectant stock strength after jerry can cleaning for HH 6 to 9.

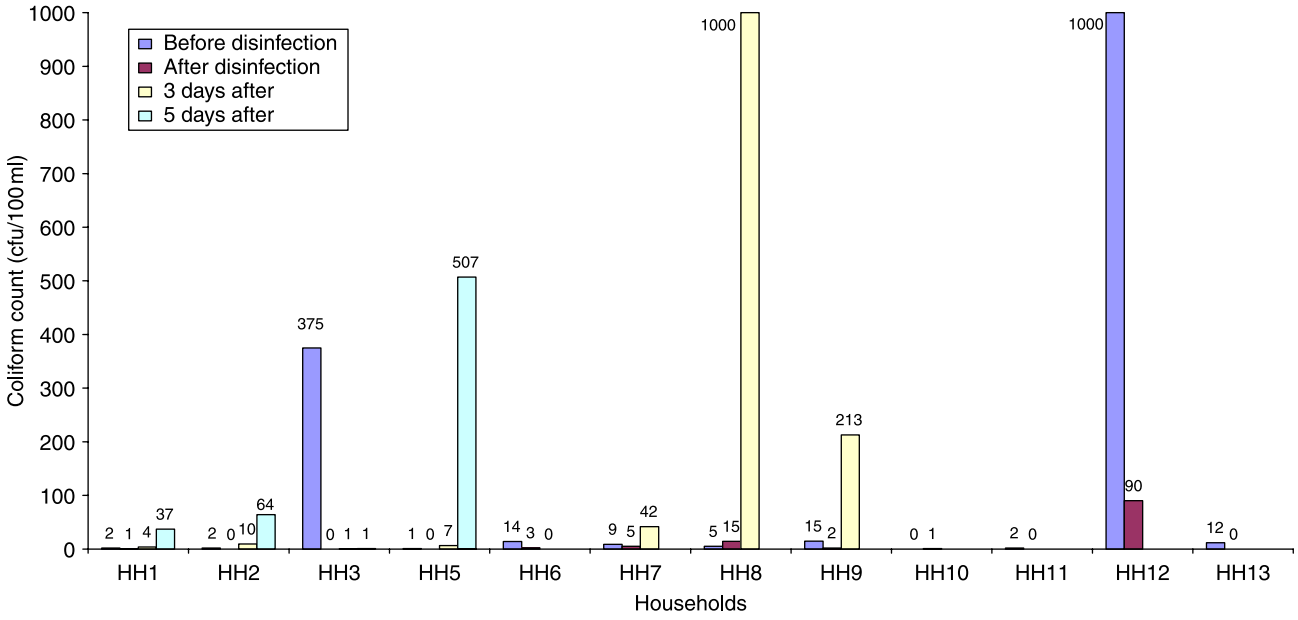

Figure 3 | Contamination of jerry cans before and after cleaning (N.B. the numbers on the diagram represent the specific cfu/100 ml count).

community. Logically this would be highlighted by a deterioration in the microbiological water quality from the point-of-supply to the point-of-use. This was illustrated by the coliform counts measured in the jerry cans prior to cleaning. It may be that this was a consequence of the nature of the emergency situation in N. Uganda; with a large population spread over a large area it was difficult to maintain a strong presence in each camp (Walker 2007). Promoting and reinforcing sanitation and hygiene practices in temporary communities is a challenge, but one of great importance. The situation may call for a community led approach, with the community identifying issues and developing solutions (Goodfellow 2007). Community awareness is needed and a community based facility for monitoring and cleaning water storage vessels may significantly improve conditions and understanding.

The results also confirm conclusions from previous studies, suggesting that the provision of improved water is not enough, and that efforts should be made to protect the water up until the point-of-use (Clasen & Bastable 2003). It is suggested that the simplest method of this is to ensure a free chlorine residual of between 0.2 to 0.5 mg/l in accordance with WHO guidelines (WHO 2004). Achieving this was not practicable in N. Uganda, where handpumps are the main water sources. Further work is needed to identify options, but it is suggested that hygiene promotion may not offer a complete solution. Household based treatment systems could be an option, but the most appropriate solution would need to be determined through pilot studies (Walker 2007). Clasen & Bastable (2003) also propose improved water storage vessels as an answer.

CONCLUSIONS

A regular jerry can cleaning procedure using high strength sodium hypochlorite has been shown to offer an effective method of alleviating contamination in water collection vessels. Its effectiveness is indicated by the reduction in thermo-tolerant coliform numbers recorded after cleaning. The chlorine demand exerted by every jerry can tested was evidenced by the trend in decreasing stock solution strength with each successive cleaning. It may be that the procedure can play an important role during epidemics of water-related diseases, especially if used in conjunction with regular water disinfection. The procedure does not substitute good hygiene practices, which are essential for maintaining water quality in the household. This study presented a modified method of intervention for agencies

operating in camp environments where it is known that water vessels are in poor condition. A further in depth study is recommended to explore the potential and limitations of this method in a wide-scale intervention.

ACKNOWLEDGEMENTS

This study would not have been possible without the support of Oxfam GB in Oxford, UK and Kitgum, Uganda and Thameswater for providing funding for the PhD studies. The views expressed in this paper are those of the authors, and are not those of Gaia Richerche, Oxfam GB or Thames Water.

REFERENCES

Balsamo, M. 2007 *Interview With Michelangelo Balsamo of AVSI*. Personal Communication 7/17/2007, Kitgum, Uganda.

Brown, M. 2006 *The Failing Humanitarian Response in Northern Uganda*. Humanitarian Practice Network, London, UK, Humanitarian Exchange, No. 36..

Checchi, F. 2006 *Humanitarian Interventions in Northern Uganda: Based on What Evidence?*. Humanitarian Practice Network, London, UK, Humanitarian Exchange, No. 36.

Clasen, T. & Bastable, A. 2003 Faecal contamination of drinking water during collection and household storage: the need to extend protection to the point of use. *J. Water Health* **1**(3), 109–115.

Curtis, V. & Cairncross, S. 2003 Effect of washing hands with soap on diarrhoea risk in the community: a systematic review. In *The Lancet Infectious Diseases*, vol. 3. Elsevier Science Ltd., London, UK, pp. 275–281.

Goodfellow, P. 2007 *Interview With Peter Goodfellow of GOAL*. Personal Communication, 7/13/2007, Bomah Hotel, Kitgum, Uganda

HRW 2005 Uprooted and Forgotten – Impunity and human rights abuses in Northern Uganda. *Human Rights Watch* **17**(12A). Human Rights Watch, Date last accessed: 4/9/2007, http://hrw.org/reports/2005/uganda0905/

Jagals, P., Jagals, C. & Bokako, T. 2003 The effect of container-biofilm on the microbiological quality of water used from plastic houshold containers. *J. Water Health* **1**(3), 101–108.

Murtagh, V. 2007 *Interview With Victoria Murtagh of Oxfam*. Personal Communication, 7/8/2007, Oxfam Compound, Kitgum, Uganda.

OCHA 2005 *Consolidated Appeals Process (CAP): Mid-Term Review of the Humanitarian Appeal 2005 for Uganda*. OCHA, Geneva, Switzerland, Date last accessed: 4/9/2007, http://www.reliefweb.int/rw/RWB.NSF/db900SID/HSHU-6DL849?OpenDocument&rc=1&emid=ACOS-635PRQ&cc=uga

Walden, V., Lamond, E. & Field, S. 2005 Container contamination as a possible source of a diarrhoea outbreak in Abou Shouk Camp, Darfur Province, Sudan. *Disasters* **29**(3), 213–221.

Walker, L. 2007 *Interview With Liz Walker of Oxfam*. Personal Communication, 7/19/2007, Oxfam Compound, Kitgum, Uganda.

WHO 2004 *Guidelines for Drinking-Water Quality, 3rd, vol. 1. Recommendations, No. 1*. World Health Organisation, Geneva, Switzerland.

WHO 2005 *Emergency Treatment of Drinking Water at Point-of-Use*. World Health Organisation, Geneva, Switzerland.

Wright, J., Gundry, S. & Conroy, R. 2004 Household drinking water in developing countries: a systematic review of microbiological contamination between source and point-of-use. *Trop. Med. Int. Health* **9**(1), 106–117.

First received 5 December 2007; accepted in revised form 20 December 2007. Available online March 2008