24th WEDC Conference Islamabad, Pakistan, 1998

SANITATION AND WATER FOR ALL

An evaluation of water urns to maintain domestic water quality

M.T. Chidavaenzi, M. Jere, C. Nhandara, D. Chingundury, and M. Bradley, Zimbabwe

UNPROTECTED SHALLOW WELLS have been used for centuries as a source of domestic water in Africa. In Zimbabwe and many other African countries such wells are still an important and perhaps, the only source of water for some settlements. However, groundwater abstracted from shallow unprotected wells is susceptible to external contamination from surface runoff, wind blown debris and unsanitary water extracting mechanisms (Barrel and Rowland 1979). Previous studies undertaken in Zimbabwe have shown that well upgrading results in considerable improvement in water quality (Morgan 1989 and unpublished work by Rukure and Chihota 1995). The upgrading process usually entails providing a well lining, windlass and supports ,a well cover, a lid and a drainage apron. Despite these improvements to family wells and to family well water, commonly practised methods of domestic water collection, transportation, storage and distribution in the home often expose water to faecal contamination (EI Attar and Khairy 1982). Thus , negating the positive public health impact of the upgraded well. A water urn was designed to interrupt the cycle of contamination of household water. This report gives design details and discusses the laboratory and field studies undertaken to evaluate the device.

Materials and methods

The water urn is a container with a close fitting hinged lid, handles and a tap outlet (Figure 1) The dimensions and size of water urns were based on water tins used by the target users. The standard water urn is 280mm in diameter, 360mm in height and contains 22 litres of water. An effective height of 325mm provides sufficient water head to impel water out of the spout and limits the settling time required to separate suspended matter from the draw out water. These dimensions ensure that at least 20 litres of water are available for domestic use. The hinged close fitting lid protects the water from external contaminants during transportation, storage and distribution. The wide mouth enables easy and thorough cleaning when refilling the urn. The lid and rim are reinforced with 3.5mm diameter wire. Handles are for lifting and securing the water urn during transportation. A tap outlet is fitted 35mm above the base to prevent contact with ground and to avoid drawing out sediments that settle below invert level. Sediments containing turbidity particles and micro-organisms should be disposed off when cleaning the urn before refilling. The design of water urns aimed to reduce the risk of water contamination during collection and transportation and to improve aesthetic and bacteriological water quality through natural water purification processes during storage and distribution. The water urns used in this study were manufactured by trained local village tinsmiths.

Figure 1. Water urn

Laboratory tests

Laboratory tests were conducted to determine turbidity and bacterial content variations in water drawn from the water urn outlet. Two water urns were filled with water from an unprotected shallow well. Samples were collected from water urns initially after 30 minutes and every 10 minutes thereafter for 3 hours. Each sample was analyzed for turbidity and bacterial content. Turbidity was analyzed by instrumentation methods employing the principles of nephelometry (Sawyer C.N. and McCarty P.L. 1978). Turbidity was measured in nephelometric turbidity units (NTU). The turbidity meter was zeroed using de-ionized water. Bacterial content was determined by using the membrane filtration technique (Cheesbrough. M. 1984, and WHO Guidelines 1984).

Field study

The field study was conducted in two adjacent villages, Rota and Chiviya, situated in Murewa district in North Eastern Zimbabwe. Sixty households with access to upgraded family wells were identified to participate in the case control design study. The sample was divided equally, with 30 households assigned to both the case and control sub-samples. Upgraded family wells and water storage vessels used by households were the objects of interest. A questionnaire was administered to each household in the case and control groups before and after the field test period. The questionnaire focused on domestic water storage and distribution practices and invited users to compare water urns with traditional containers. In Rota village, 30 households were designated as the case group, and each household was provided with a user manual and two water urns to substitute their traditional containers (tins). The 30 households in the control group in Chiviya village were not provided with water urns. During a four week period, two samples were collected from upgraded family wells and from either water urns or traditional containers per each household that participated in the field test. Samples were collected using sterile bottles. Samples were obtained from traditional containers using utensils used by household to distribute water for domestic purposes, and from water urns by running water directly into sample bottles. Water samples were collected between 7 am and midday. Samples collected for bacteriological analysis were transported in cooler boxes to the District Hospital Laboratory. The samples were analyzed using the membrane filtration technique to determine the concentration of coliform indicator organisms (Cheesbrough. M. 1984), and WHO Guidelines 1984). From each sample collected ,100 mls of water were filtered to deposit organisms on the membrane. The membrane was then incubated on a selective media, Membrane Lauryl Sulphate broth, at 37^0C for 24 to 48 hours and at 44^0C for 16 to 18 hours for the enumeration of total coliform and faecal coliform densities respectively. Bacterial counts in the upgraded family wells supplying each household were used as baseline for comparing the effects of water urns and traditional containers.

Data analysis

The data were analyzed using Microsoft Excel. Differences in water storage and distribution practices, and in bacterial counts between household wells and containers were determined by statistical tests.

Results

Samples yielded scanty faecal coliform data. Total or general coliform bacterial counts were used to compare water quality.

Laboratory tests

Results of the initial laboratory studies conducted to establish sedimentation patterns and bacterial die -off rates in water urns are shown in Figures 2 and 3. The data indicated an initial rise in turbidity within the first hour after filling the urn with water as suspended solids concentrated in the invert (draw out) level under the influence of gravity (Figure 2). Thereafter there was a more or less linear decline in turbidity to a stable equilibrium reached after approximately two and a half hours. Bacteriological data showed that bacterial counts remained stable for about an hour from the time of filling the urn with water (Figure 3). Thereafter there was a rapid decline in bacterial count over the next one and a half hours followed by a prolonged slow decline.

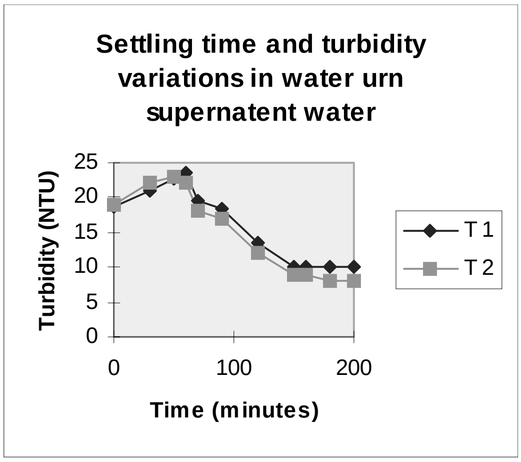

Figure 2.

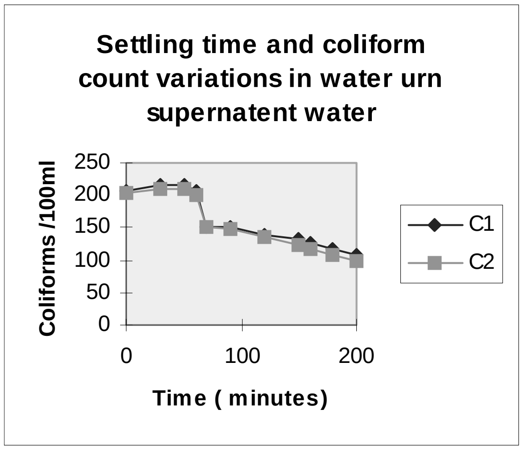

Figure 3.

Field studies

Questionnaire study

Household in either case or control group stored at least 50 litres of water for domestic purposes before intervention. In the case group 61 per cent of households stored water in open containers whereas 43 per cent of households in the control group stored water in open containers. Only 7 per cent of households in the case group stored water in closed containers whilst 27 per cent of households in the control group stored water in closed containers (Table 1). These differences were statistically significant (X^2=8.09; P<0.01).

Table 1. Domestic water storage practices in case and control group households before the field trial

In the case group 77 per cent of households used cups while 23 per cent used floating vessels to distribute domestic water. In the control group 67 per cent of households used cups while 37 per cent used floating vessels to distribute domestic water (Table 2). These differences were not statistically significant (X2= 0.72 ; p>0.05).

Table 2. Domestic water distribution practices in case and control group households before the field trial

Table 3. Domestic water distributor placement practices in case and control group households before the field trial

In the case group , 40 per cent of households kept utensils used to distribute domestic water on trays while 53 per cent of households hung the utensils on walls. In the control group, 53 per cent of households kept utensils used to distribute domestic water on trays while 47 per cent of households hung the utensils on walls (Table 3). These difference were not statistically significant (X^2 =0.64; p>0.05).

Water urn users observed that the urns provided cooler and cleaner water and protected water from hand dipping. The villagers requested for more water urns.

Bacteriological water quality

Field trial data analysis indicate that on average, the wells supplying the case households had higher total coliform bacterial counts than those supplying control households (Table 4). The contamination odds risk ratio for control to case wells was 1:1.056. A factor of 0.947 was used to moderate mean bacterial counts in water urns. Further analysis of these data indicate that bacterial loads observed in water urns were significantly lower than those observed in the corresponding supply wells (T-test: t=3.97 df=55 p<0.01). Whereas bacterial counts observed in water containers used in the control households were basically similar to those observed in the corresponding supply wells (T-test; t=0.2 df=57 p>0.05).

Water stored and distributed from water urns had significantly lower bacterial loads than water from corresponding supply wells, whereas water stored and distributed from traditional containers had higher bacterial loads than water from corresponding supply wells (Figure 4). The relative risk of water contamination during storage was 3 times more in traditional containers than in water urns (Table 4). The quality of domestic water stored in water urns was significantly better than that of water stored in traditional containers (T-test; t=2.88 df=113 p<0.01).

Discussion

Our results show that under quiescent conditions relatively coarse turbidity particles and bacteria settle past the

Table 4. Mean and moderated bacterial loads for case household wells and water urns and control household wells and traditional storage containers

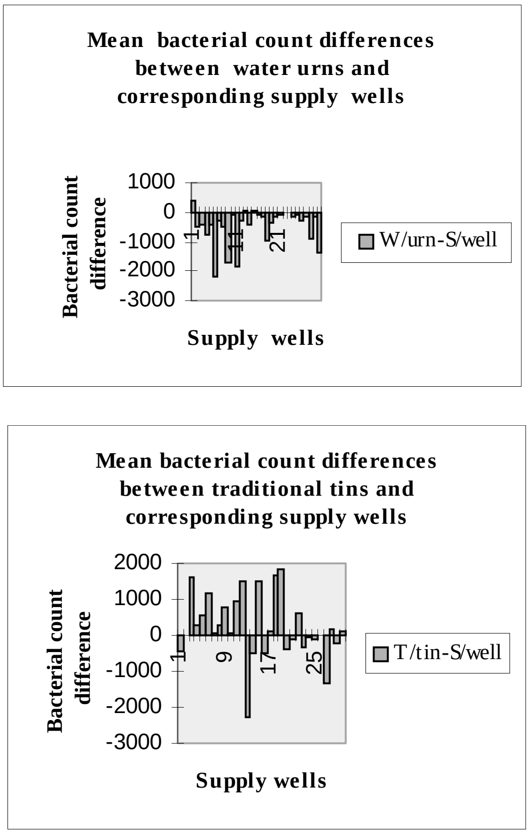

Figure 4.

water urn outlet. The initial rise in turbidity around the outlet after water has been stored for about one hour followed by a rapid decline coincides with the rapid decline in bacterial load around the outlet. Metcalf & Eddy state that in waters containing high concentrations of suspended solids, the contacting particles tend to settle as a zone leaving a relatively clear layer of water above the particles in the settling region. This suggests that relatively coarse turbidity particles in water urns may entrap bacterial cells as they settle under gravity to below invert level. Equilibrium is reached after a settling time of about two and a half hours (for this water) when all the coarse particles have gravitated past the outlet. However the results show that bacterial counts continue to decline slowly thereafter. The slow decline may be due to declining nutrient supply and reduced temperatures that accelerate the natural die-off rate of microorganisms. Sawyer C. N. and McCarty P. L. observed that organic material causing turbidity serves as food for bacteria. The close fitting lid and drawing water from the water urn tap are therefore effective ways of reducing the risk of external contamination. An optimum drinking water settling and storage time of more than two and half hours is recommended. Results show that domestic water in the control group households was stored under significantly better conditions than water in the case households before intervention with water urns. However, there were no significant differences in water distribution practices between the case and control group households. Water from water urns had significantly lower bacterial densities than water from the supply wells, whereas water from traditional containers had bacterial loads similar to those of the supply wells. Water urns effected a reduction in bacterial loads whereas traditional containers maintained the initial bacterial loads. The bacterial loads in domestic water stored in water urns was three times lower and better than that of water stored in traditional containers. Water urns, therefore, improved the bacteriological quality of drinking water without the use of conventional chemicals and disinfectants. The results also show that water urns maintain or improve drinking water quality only when used properly. User instructions should therefore, emphasize practices that promote water storage before use and proper use of water urns. Generally, the use of water urns significantly interrupts the faecal-oral route of disease transmission. Water urns can be made by local tinsmiths. With minimum training and instruction, local tinsmiths can use locally available materials to upgrade water tins to water urns. Water urn users observed that water urns provided cooler water, enabled safe storage and facilitated hygienic hand washing. Water urns are therefore an affordable, sustainable, acceptable, appropriate and transferable alternative technique for safe storage and use of domestic water in rural areas and other similar situations. Furthermore water urns can be used in various premises and situations such as, classrooms, business premises, health centres, hospitals, offices, gatherings and as models for hygiene education. There was no way of establishing for how long water had been stored in either the case or control households. Although water is obviously collected and stored as need dictates. In general, household water storage containers are filled either in the evening or early morning.

Acknowledgements

We gratefully appreciate the support given by the Blair Research Institute. We thank Mr. E. C. Murahwa (the District Environmental Health Officer for Murewa), Mr. Cuthbert Chidavaenzi (the Environmental Health Technician for the study area) and all the individuals who participated in the study. This work was funded by the Swedish International Development Agency.

References

BARREL, R.A.E. and ROWLAND, M.G.M., 1979, The relationship between rainfall and well water pollution in a West African (Gambian) village. Journal of Hygiene 83;143-150.

CAMPBELL STU., The home water supply. How to find, filter, store and conserve it. A Garden Way Publishing Book.

CHEESBROUGH, M., 1984, Bacteriological testing of water supplies. In Medical Laboratory manual for Tropical Countries 1st edition, Theftford Press Ltd England P. 212.

CHIDAVAENZI, TICHAFA MORRIS, August 1995, The Hygiene Enabling Water Urn. A text from Zimbabwe's Blair Research Laboratory.

V.N., CHIHOTA and Z., NYATI, An evaluation of upgraded family wells with particular reference to water quality (unpublished).

CLAIR N., SAWYER and PERRY L., MCCARTY, 1978, Chemistry for Environmental Engineering. 3rd edition, McGraw-Hill Book Company. P. 331.

EL ATTAR, L., 1982, The sanitary condition of rural drinking water in a Nile Delta village. Journal of Hygiene, 88, 63-67.

KHAIRY, A.E.M., 1982, The sanitary condition of rural drinking water in Nile Delta Village. Journal of Hygiene 88, 57-61.

MANN, H.T., and WILLIAMSON D., 1976, Water Treatment and Sanitation. A handbook of simple methods for rural in developing countries.

METCALF and EDDY, Wastewater Engineering, Treatment, Disposal and Reuse. Third Edition, 1991, Revised by George Tchobanoglous and Franklin L. Burton. McGraw- Hill, INC P.229-230.

P., MORGAN, 1990, Rural Water Supplies and Sanitation. A text from Zimbabwe Blair Research Laboratory.

G., RUKURE, S., MTERO, C., MUKANDI, C., NHANDARA and M., JERE; The effects of well structural features on bacteriological quality of water for domestic use in Zimbabwe (unpublished).

WASHINGTON DEPARTMENT OF ECOLOGY. Water Quality Guide; Recommended pollution control practices for home owners and small farm operators. November 1994.

WORLD HEALTH ORGANIZATION, 1984, Guidelines for drinking water quality. Geneva.

CHIDAVAENZI, M.T., Ministry of Health and Child Welfare, Blair Research Institute.

JERE, J.

NHANDARA, C.

CHINGUNDURY, D.

BRADLEY, M.