Disinfecting tube-well water — the evolution of a new technology

by Richard Luff and Enamul Hoque

In crowded camps, well water is easily contaminated and refugees susceptible to disease. How did a combination of fieldworker initiative, student design, and a little improvisation result in a simple — if short-term — chlorine-dosing device?

IN MARCH 1992, two large, but quite unconnected, refugee exoduses occurred more or less simultaneously in South Asia. About 250 000 refugees from Myanmar (Burma) fled into the Coxs Bazaar district of south-east Bangladesh, whilst about 80 000 refugees fled from Bhutan, across India around the Darjeeling area, and into Eastern Nepal.

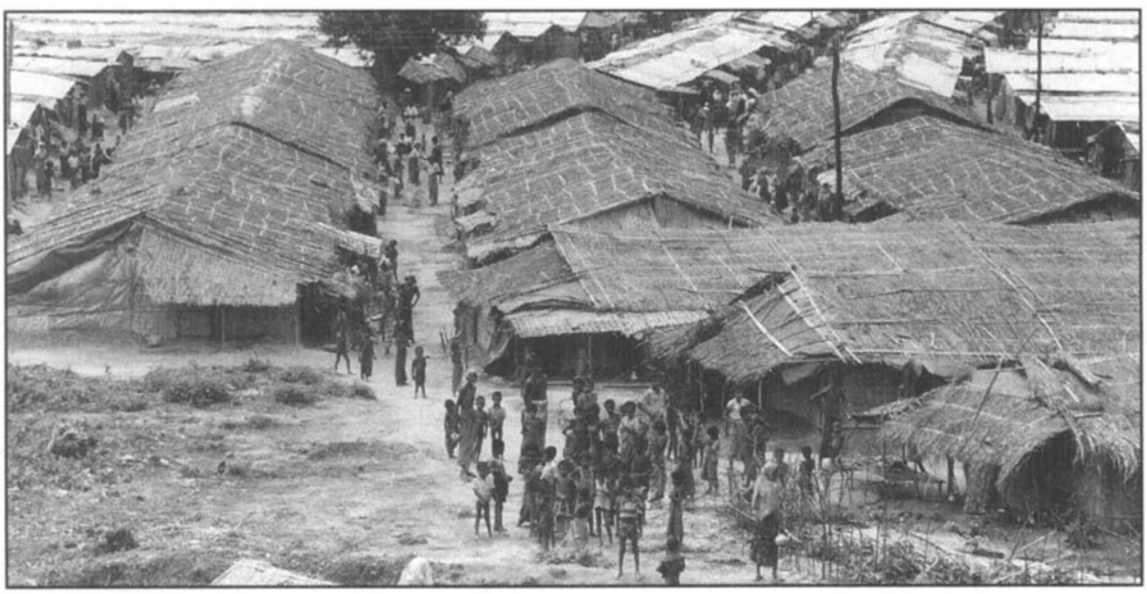
In Bangladesh, Oxfam's objective was to quickly set up surface-water treatment systems in the groundwater-poor area of Teknaf for 40 000 of these refugees who were without potable water; the remainder were drawing water from government-provided shallow tube wells, hand-drilled in alluvial soils, common in Bangladesh, and fitted with suction handpumps. These tube wells generally provide potable water, though the density of refugee settlement on the limited uncultivated land available meant that latrine provision at a safe distance from tube wells was very difficult to achieve. Furthermore, refugees are usually most susceptible to disease during the first months, and indeed it was only after six months or so that morbidity/mortality rates decreased and stabilized to levels comparable to the surrounding villages.

Given Oxfam's experience in water treatment in the Myanmar refugee camps in the south of Coxs Bazaar district and our access to supplies of chlorine and an Oxfam/DelAgua faecal coliform testing-kit, we were often called upon to test and suggest solutions for dealing with wells suspected of having faecal contamination. DPHE (The Department of Public Health Engineering, responsible for drilling these wells) practice was to super-chlorinate wells on completion before they were pumped out and handed over for use. This clearly did not offer continued protection, however, where post-drilling contamination occurred (due to latrines), so the Oxfam team initially tried intermittent, low-level chlorination with HTH solution, before dropping 50g-pieces of slow-dissolving chlorine tablets (trichloroisocyanuric acid, used only in the short term as this type of chlorine should not be used for more than three months) down the tube well by removing, then replacing, the handpump.

This gave mixed results, as the level of contamination and the rate of discharge of water from the pump varied from well to well, though we did find that we could achieve an acceptable level of chlorination (0.1-0.5mg/l) for several days using this method. But it was very labour intensive, and proportional dosing was impossible, with concentration build-ups overnight, making pumping water to waste first thing in the morning imperative. In the circumstances, the government, the UNHCR, refugees, and relevant health agencies considered these efforts sufficient, and they were certainly an improvement on the previous situation.

In the middle of attempts to deal with this problem, Oxfam undertook a water/sanitation assessment in Nepal, where the efforts of another international agency to improve water and sanitation facilities were considered insufficient in the light of the deteriorating health of the Bhutanese refugees. Some six refugee camps were located in the Terai (southern plains) area of Nepal; the northernmost camps were located in a rich, shallow aquifer with a high stone/boulder content, while the three camps further south were situated on alluvial soils, very similar to those found in Bangladesh.

Refugees in the southern camps obtained water from tube wells, while their northern counterparts had open wells, often with very high levels of contamination. While it was clear that the hand-dug wells in the northern camps would have to be phased out as



Howard Davies/Oxfam

Rohingya refugees living in Dumdumia camp, Bangladesh.

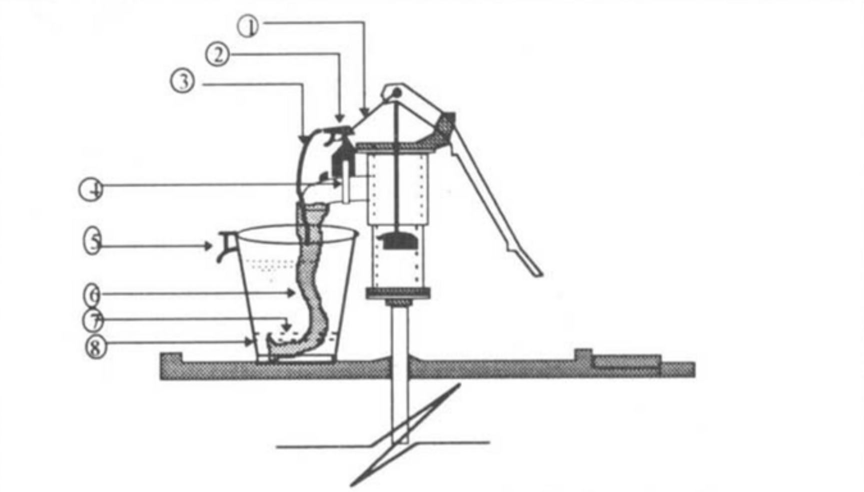
soon as possible and replaced by a deep boreholes/piped water system because of the shallow aquifer (1m below ground) and high transmissivity of the soil, Oxfam and the health agency argued strongly about which sort of water supply was most suitable for the southern camps. Oxfam was very much in favour of continuing to use the shallow tube wells, in conjunction with intermittent chlorination and siting the tube wells sufficiently far from the family latrines being proposed, while the health agency and UNHCR were in favour of deep boreholes, equipped with submersible pumps for both southern and northern camps. Oxfam's arguments for maintaining tube wells were:

- they are less complex and, therefore, a more appropriate technology for rural Nepal;
- they would provide a level of service similar to what was available to local Nepali villagers;
- they are a cheaper option; and
- this level of service was considered acceptable for refugees in Bangladesh, so why not for refugees in Nepal?

UNHCR and the health agency argued that:

- shallow groundwater from tube wells would be very prone to contamination. (We found out, subsequently, that this was being caused partly by a drilling mud consisting of cow dung and water); and
- there was no scope for providing a continual chlorine residual in tube-well water.

On the basis of Oxfam's recent well-chlorination experience in Bangladesh, Oxfam could offer no guaranteed effective solution to providing a continuous chlorine residual in water drawn by handpump from tube wells, which meant that, ultimately, deep boreholes were drilled and piped water supplied for the southern camps, instead of continuing to use handpumps. As a long-term water-supply option, it was perhaps not the best, but the shorter-term health concerns prevailed. The challenge remained: 'How can we provide a chlorine residue for shallow tube wells fitted with suction pumps?'



1. pulling clip with 12mm active gap(12mm shorter than the ultimate length)
2. complete set of 500ml spray gun full of 1% cl_2 solution
3. plastic hose(IV infusion pipe) connected between spray nozzle & perforated extended hose
4. steel clamp to fixed the solution bottle on the outlet
5. collection tap
6. perforated extended rubber hose from the handpump out-let to the bottom of container
7. 2 layer 1mm plastic mesh over the orifice
8. container

Figure 1. Handpump chlorination device (first trial, Dumdumia 2 Camp).

Improvisation

In discussions with Peter Howsam of Silsoe College, it was proposed that an MSc project could be devoted to developing a chlorine-dosing device, which could be retro-fitted to a suction-lift handpump. Student Peter Clayton, began to design and build a simple device, operated by the action of the pump handle, whilst simultaneously discharging water.

In October 1993, Oxfam Bangladesh agreed to test this handpump chlorination device, and this was carried out by the team working on water supply in the refugee camps. Finding all of the materials required by Peter's design — such as a swivel lever, bearing back cam and 1cc reciprocating pump — proved difficult, so the team, based at Dumdumia 2 camp, improvised, substituting the spray-gun from a 500ml insecticide-spray bottle for the chlorine-solution injector, in order to pump chlorine at each stroke. The solution bottle was clamped on the outlet of the handpump, and the trigger of the spray was connected to the upper arm of the handpump lever by a guided clip, which allowed the trigger to be pulled for 12mm, in order to spray chlorine to the discharge outlet through a narrow plastic hose. An extended, perforated-rubber hose diffused the chlorinated water through a double layer of 1mm mesh at the bottom of the container. A large container was found to give more contact time, though for the handpump, a maximum 100-litre size was convenient (see Figure 1 above). This system had some disadvantages; the chlorine solution had to be topped up frequently, and the components were not very durable.

Recycling

By the end of 1994, when the team had been looking for an alternative design for a year, we discovered some scrap materials from the spinning mill, such as a swivel lever and bearing back cam with shaft. These were used to create a reciprocating motion for the small solution pump, which was a 5cc modified hypodermic syringe pumped by a plastic piston, both the suction and delivery non-returnable valve with thin plastic. The whole set was assembled on the outer body of the pump-head. The system operated for a week at Oxfam's staff quarters in Teknaf — when attempted in the refugee camp, it was damaged by refugee children in an hour.

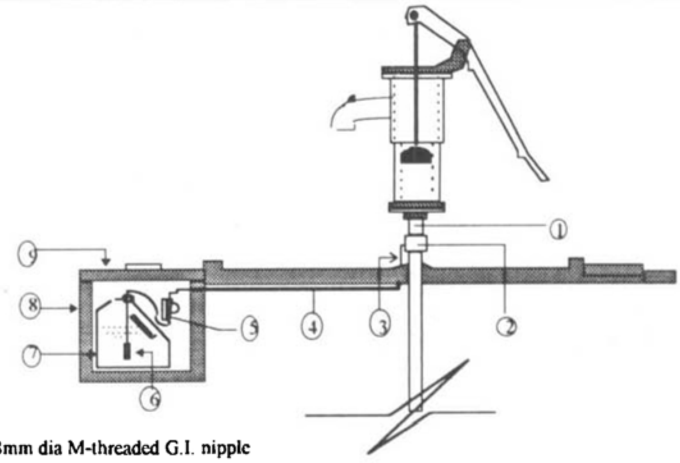
Given the local moulded head (No.6 Unicef model), we used a 500ml baby feeder upside down, clamped with a device embedded on the outlet of the pump, and connected with the solution pump (the original design showed the solution bottle in the side of the handpump head). As with the first trial, however, this design had the problem of matching the dose of 1 per cent solution with the yield of the handpump to get the desired chlorine residual. A good-yield suction pump can give >1 litre per stroke and a poor one <.5 litre, but the design dose remained 1ml of 1 per cent per stroke and, moreover, if the pH is <6.5 or >8, corrosion of the components would be a problem.

Thus, with both designs it was immediately apparent that both the chlorine reservoir and dosing pumps were vulnerable to accidental damage and tampering. So a further improved design evolved, in which a reservoir of larger capacity (hence reducing the time between filling), based on a plastic bucket was sunk into the concrete apron and provided with a concrete lid, which formed part of the slab, complete with a lockable lid. From the bottom of the bucket, a 1mm plastic tube was connected into a small taping at the base of the pump cylinder, below the bottom of the pump's stroke.

To achieve this, a 5mm (M) elbow nozzle was taped into the 38mm (11 1/2")

G.I. socket at the top of the handpump rising pipe, and this elbow was connected to a PVC casing pipe underneath the apron, running to the solution reservoir and regulating system (see Figure 2). A surgical valve consisting of a wedge, in which the tube was sandwiched, complete with a knurled knob, enabled the flow of chlorine solution to be regulated to give the correct dose for that particular well with its particular level of contamination, and this could be adjusted until the right chlorine residual was achieved. Of course, the level of chlorination can also be adjusted by altering the strength of the solution, but a standard mix should be decided upon and adhered to, in order to avoid confusion with mixing and administering several different strengths of chlorine solution.

The final modification, (pictured right), was put together very simply from the IV infusion set and a few extra materials.



1. 38mm dia M-threaded G.I. nipple
2. 38mm F-threaded G.I. socket
3. 5mm elbow shape brass nozzle
4. 5mm concealed plastic pipe(IV pipe set) through 12mm PVC casing
5. dose regulator(IV set)
6. 10mm foot valve(IVset)
7. plastic container
8. concrete/masonry box
9. ferrocement/wooden lid(key-lock system)

Figure 2. The 1994 final modification.

Component	*Cost in £ sterling*
1. 1/2"(M) G.I. nipple	0.50
2. 1/2"(F) G.I. connector with 5mm F-threaded hole	1.50
3. 5mm (M) brass-hose coupler (L-shape nozzle)	1.00
4. 5-litre plastic jerrycan for chlorine solution	0.50
5. 1" or 3/4" dia. PVC casing pipe (1.5 m length)	0.50
6. Hand-made foot-valve for 5mm suction hose	0.50
7. IV infusion set for plastic hose, regulator etc.	0.50
8. Concrete box & ferro-cement lid (including labour & materials)	5.00
OR	
Complete apron cost (in case of new construction)	15.00
Total cost of system in existing apron	**£10.00**
Total cost with new apron	**£25.00**

Technical data

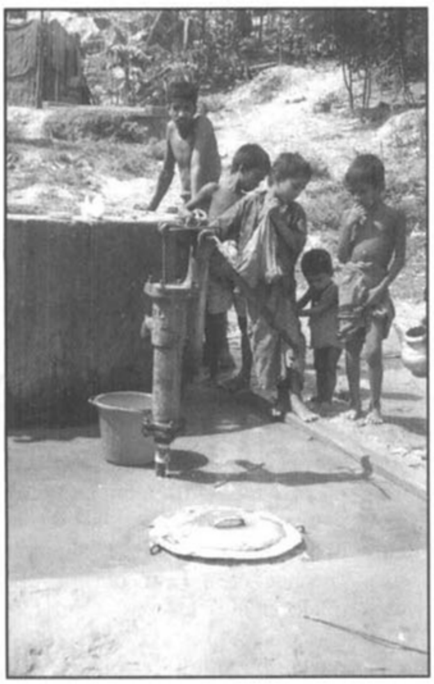
- No special tools are required, though the handpump can either be drilled out *in situ* or removed from the well so that a workshop technician can drill a hole to produce a threaded 5mm hole in the side which enables the nozzle to be attached; or it can be fixed, via a nipple, by gas welding, at an approximate cost of £0.25.
- Use either a 1 per cent chlorine solution, or a commercial liquid bleach, available every where in Bangladesh in litre bottles of 1 per cent strength. After eight hours, the solution flow should be adjusted to maintain the same residual, implying that, after eight hours, the chlorine loses strength. A 5-litre solution will last between one-and-a-half and two days. The chlorine has a noticeable effect on both the leather washer inside the pump, and on the screw connecting the leather bucket to the piston rod of the handpump.

Limited but useful

This system was built and tested successfully in 1994, and used on handpumps attached to Unicef pond-filters with encouraging results. It is, of course, accepted that dissemination of this form of dosing should incorporate hygiene promotion/information, so that users understand that their containers should be left to stand for at least half an hour to achieve the required contact time (under normal pH conditions).

The system has its limitations, as it is only suitable for shallow suction pumps. The need to find a solution for reciprocating or progressive cavity handpumps is less pressing, as water drawn from greater depths is less likely to become contaminated. Also, the time it takes to drill a well mechanically (more likely for a deeper well which requires either a reciprocating or a progressive cavity handpump) in an emergency situation, would often preclude its use in the early stages. There may be instances, however, when the chlorination of wells fitted with such handpumps is desirable, in which case the development of a simple proportional doser for this type of pump could be useful.

This simple device has a role to play in a limited number of situations, and probably only for short periods of time, but it does satisfy the demands — where poor health conditions dictate — of providing a chlorine residual in water drawn from tube wells with handpumps. Because of that, it provides a technical solution to a particular problem and, therefore, would have been invaluable in convincing all parties that handpumps were the best option for those southern refugee camps in Nepal in 1992.



Richard Luff

Children gather at the handpump fitted with the chlorination device.

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Oxfam worked in the refugee camps in Bangladesh until the vast majority of Myanmar refugees finally returned home at the end of 1996 (although Oxfam hears of continued persecution). Oxfam's involvement with water supply and sanitation for the refugees in Nepal ceased some months later, once the health situation had stabilized, so we have no insights into how the water systems continued to function in the medium term. Refugees remain in Nepal, however, presumably served by water from piped systems.