

PEOPLE-CENTRED APPROACHES TO WATER AND ENVIRONMENTAL SANITATION

Paying too much for purity? Development of more appropriate emergency water treatment methods

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The provision of an adequate water supply in the early stages of a rapid onset crisis often requires use of contaminated surface water where normal supplies are disrupted or are not available. In these situations people affected are invariably without basic services for a period of time and often denied any say in the type of "emergency assistance" that are provided for them. This creates an environment in which accountability for the choice of assistance provided is minimal. Some organisations place a premium upon providing Mobile Package Water Treatment Systems (MPWTS), which may cost substantial amounts of money, often do not cope with high suspended solids loading and are very dependent on imported technology and personnel. In order to challenge the assumptions made by commercial companies who developed these units, Oxfam in collaboration with the University of Surrey, set out to develop its own water treatment options that would be more closely aligned with peoples needs.paper

Focusing on health not water purity

The greatest short-term water-related health risks in the overwhelming majority of disaster situations are due to the presence of pathogens (microbiological contamination). Chemical contamination is rarely an immediate health concern. In the early stages of water supply in an emergency, water quality (and quantity) may well fall below WHO recommendations, in which case the initial emphasis will be on raising both quality (and quantity) to fall within acceptable limits in the *shortest possible time*.

In choosing a water source(s), the quality of raw water has to be balanced against the quantity available. From a health point of view, *a larger quantity of relatively good quality water is better than a small quantity of very high quality water*. An understanding of water related disease classifications (Caincross, Feachem 2000) and preventative strategies appropriate for each demonstrates this and Burkholder and Toole (Burkholder, Toole, 1995) in their paper express this view. The SPHERE guidelines (SPHERE, 2003) specify the following indicators for emergency water supply; maintaining turbidity below 5; maintaining a chlorine residual of 0.3-0.5 mg per litre; there should be 0 faecal coliforms/100ml at point of water delivery; the recommended figure of 15 litres / person / day is used for water supply. The parameters are relatively limited, reflecting a focus on the greatest priorities in an emergency

It is not possible to "weight" the potential negative health impact of each water related disease in an emergency situation and thus to dedicate resources to a range of prevention strategies according to risk. Despite this many commercial companies who produce high cost Mobile Package Water Treatment Systems (MPWTS) for emergency use, implicitly assume that dealing with water borne diseases is the

most significant health risk and therefore seek to be able to produce water of the highest quality that is pathogen free. "...the preoccupation with strictly water-borne epidemics of cholera and typhoid which occurred in some European towns in the last century and the first quarter of this one, and were largely caused by urban water supplies with inadequate treatment facilities" (Caincross, Feachem 1994). It is perhaps this preoccupation, combined with a desire to apply European/North American drinking water standards to crisis response, often in developing countries, that leads commercial companies to manufacture expensive MPWTS and for some relief agencies to purchase these.

There is undoubtedly an emotional aspect to dealing with large outbreaks of water-borne diseases and no one would wish to be faced with the situation in the Rwanda refugee camps in Goma, Zaire in 1994, where a cholera outbreak killed perhaps 20,000 – 30,000 people in a period of about 3 weeks. This, sometimes combines with the desire to show news camera/reporters that a relief agency can provide assistance within hours of arriving at a crisis location. This no doubt places a skewed premium on MPWTS that appear to offer "instantaneous" water supply solutions. However the difference of a few hours or a day in establishing a water supply from a MPWTS compared to a more durable approach is very unlikely to have much impact on morbidity and mortality rates due to diarrhoeal diseases.

Problems with existing treatment systems

It is necessary to have an understanding of the treatment challenges likely to be encountered. Surface water sources often present the quickest option for water supply in the short

term, but the biggest treatment problems encountered are often the removal of suspended solids. Therefore any system chosen must be robust enough to withstand the rigours of treating water with high-suspended solids loading.

In 1995 the key water supply relief agencies knowing this to be a major challenge for some MPWTS on the market, undertook equipment trials to test 8 units for their ability to cope with high-suspended solids loading, along with looking at other criteria (ICRC 1995). What was clearly apparent from this experience was that all manufacturers neglected to provide any data on how their units performed when challenged with high suspended solids loading. Furthermore several performed very badly and blocked quickly, providing rapidly diminishing quantities of product water.

Finally questions have to be raised about the capital and running costs of some of the units currently available. Funding for relief agencies to respond to crisis is complex and savings on equipment do not necessarily enable funds to be released for expenditure on other forms of important assistance. Nevertheless, there must always be questions asked about high expenditures, especially where added health value is debatable. In this regard purchase of units which can cost from \$30,000 – 100,000, combined with high running costs due to the need for imported consumables, spares and specialist operation skills make unit production costs for water extremely high. Finally, in the medium term, these technology choices are not suitable for affected communities to operate, let alone understand.

Looking for more appropriate solutions

The objective, albeit brief assessment at the interagency water treatment unit tests of MPWTS units, led Oxfam and MSF Belgium to develop their own treatment approaches. In the development of these Oxfam put a premium on cost, robustness, and simplicity, in order to place its technology choices much closer to an affected community's needs and sought to engineer systems into the well-known Oxfam emergency water tanks. However Oxfam realised from the interagency meeting that its existing granular filter systems should be considered as most appropriate for post emergency situations, as these treatment methods take a few weeks to establish (but are more sustainable). Therefore there was a need to develop a physico-chemical based system with a speed and efficiency suitable for use during the early stages of an emergency response. In fact, (since the early 80s), Oxfam had already undertaken simple batch dosing using aluminium sulphate and subsequent plain sedimentation in Oxfam tanks, but became aware of the limitations of the practice because of lack of process control and variable product water quality. Since the late 90s, this has led to the development and introduction of the upflow clarifier, built into an 11,000 litre tank, which would complement the existing Oxfam approach. Further details of both systems are provided below.

The first phase response, the upflow clarifier

Recognising the limitations of the granular filtration approach, in 1995 Oxfam looked for a treatment system that could be built into its 11,000 litre water storage tanks. It sought to expand its collaboration with the University of Surrey, and Oxfam initiated a project, which was generously funded by DFID and Oxfam. There were a number of parameters, which were chosen to help guide the design of a potential system. These were; able to operate with a very wide range of turbidities; suitable for gravity as well as pumped water supply; affordable; and simple to operate.

A variety of trials on different treatment configurations were undertaken, which led to the examination of a conventional water treatment technology in the form of an upflow clarifier. Investigations were undertaken into the possibility of adapting this for emergency situations using a clarifier in conjunction with chlorine disinfection.

The International Committee of the Red Cross (ICRC) hosted another Inter-Agency Technical Meeting in Geneva in July 1998, on the site of an old water treatment station on the River Arve. By the time of this meeting the original clarifier design had two enhanced features. The first was to add a coiled pipe flocculator. The second, and most significant change was the addition of a fabric 'polishing filter' consisting of a layer of geotextile fabric of high porosity stretched over the top of the tank just underneath the outlet, for final polishing purposes.

During this meeting, the clarifier was run for an extended period of 16 hours for the first time ever, with an initial flow of 5m³/hr, which was subsequently increased to 7m³/hr. During the trial the influent water turbidity rose to 600NTU and the system was still able to provide product water with <10NTU. "The change in throughput rate clearly affected treated water quality but the tendency of the system's performance to gradually improve after a disturbance, a feature noted on full scale upflow clarifiers in the UK, was apparent from the on-going results. After continuously running for 16 hours, sludge removal from both the base of the second stage flocculator and from within the clarifier cone was completed by simply opening valves on the drain lines with the system still in operation" (Clarke 2002).

While the fabrication used in Geneva needed significant modifications, the system demonstrated its abilities to deal with very high-suspended solids loading and the simplicities of its operation once set up. By year 2000 the clarifier had been considerably enhanced. The new fabrication was lighter, quicker to assemble and had an improved polishing fabric holding down arrangement to facilitate speedy filter cleaning and change over.

One major quality limitation of this system is its inability to eliminate some protozoa such as Giardia, which are very chlorine resistant. This is acknowledged and indeed Oxfam

has therefore undertaken trials with a membrane filter as a tertiary treatment system for protozoa removal. However the cost of membrane filters remains relatively high and a decision has been made not to stock these as part of the standard kits, but rather keep open the option of supplying these as an extra.

This work has also been accompanied by the development of an Oxfam suction side doser kit, which was an evolution of earlier development by MSF Belgium and the assembly of an Oxfam chlorine doser based upon a floating bucket system. Both systems have been tested and proved during work undertaken by CEHE at Surrey University. The upflow clarifier in its current form has been tested by CEHE for 3 years and continues to deliver good results and prove its potential. This current version has also been used by another relief agency ACF, both on trial in Spain and in Mozambique.

With some years of development and operation of the upflow clarifier system, there is a degree of confidence behind it and it is now stocked as a kit in the Oxfam emergencies warehouse, complete with an instruction manual (Luff, 2000). (Cost for an Upflow clarifier kit, Oxfam T11 tank, suction side doser and chlorine constant head doser are about £4600) However the demand for the system has been disappointing, in part due to the relative absence of large refugee camps, e.g. as found in and around Rwanda in 1994.

Therefore there are a number of further developments that it would be worthwhile Oxfam undertaking.

- Adapting these systems to provide water for groups of 500 – 5000 people, which could be useful in a wider variety of crisis situations beyond large refugee camps.
- There is a need to improve some elements of the clarifier system, perhaps by experimenting with simplification of the system and providing better instructions for installation and operation
- If the issue of protozoa removal needs to be addressed, then further work needs to be undertaken to provide a 'bolt on' tertiary water treatment stage, probably using membrane filters

Granular filtration systems for use in the post emergency phase

Oxfam's work with slow sand filters was initiated in 1986 in collaboration with Nigel Graham at Imperial College. This work resulted in the production of Oxfam slow sand filter kits, which have been used in Ethiopia, Bangladesh in 1992, Rwanda in 1993 and again in 1996. However there was no pre-treatment equipment available and it was often necessary to use coagulants, or raw water sedimentation tanks during peaks of turbidity in order to prevent blocking of the slow sand filters. It was apparent to the author from Oxfam's work in Bangladesh in 1992, that there was a need for a prefilter built into an Oxfam tank (Luff, 1992). The team in Bangladesh built and ran a prefilter in 1993 and Paul

Naylor based his M Sc. at Imperial College on exploring this idea further (Naylor 1993).

Work on developing this idea was seriously initiated in 1994, in conjunction with Surrey University, with an early proto-type of a prefilter built into an Oxfam tank with a raised floor, operating on an upflow basis. This raised floor was built 300mm above the tank base and supported about 1m depth of granular material on it. The void below the raised floor allows more efficient backwashing of solids trapped in the filter media and subsequent removal when the filter is rapidly drained down.

"In 1996, two pre-filters built in Oxfam tanks were constructed at Nyabwishongwezi, Northern Rwanda, to evaluate the long term structural behaviour as well as their operational performance. Filtration rates of between 0.6-0.8 m³m-2h-1 were applied to the upflow pre-filters. The pilot plant pre-filters achieved both turbidity reduction and suspended solids removals in the range 60-70% with a significant 75-85% faecal coliform removal" (Clarke, 2002). Once the success of these was proved, an Oxfam kit was developed that enabled an Oxfam 11,000 litre tank to be converted into a prefilter, in conjunction with locally available washed and graded stone with a newly engineered raised floor incorporated into the new kit. (Cost of prefilter kit and Oxfam T11 tank is about £3000)

Extensive tests and documentation of both prefilters and slow sand filters has been undertaken by Surrey University to prove the value of the multi stage approach. "Prefilter loading rates in the range 0.6-1.0 m³m-2h-1 are considered appropriate to achieve >75% overall suspended solids removal, while slow sand filter loading rates in the range 0.1-0.2 m³m-2h-1 are recommended as a basis for design" (Clarke, Jones, Evans, Crompton 2003). The existing Oxfam slow sand filter kit was re-examined and the specification upgraded to enable these to be run at a loading rate of 0.2 m³m-2h-1, (up from 0.1) in order to make these more capital cost effective, albeit with additional maintenance requirements. (Cost of a SSF kit and Oxfam T70 tank about £7000) The equipment developments and modifications were then incorporated in the new Oxfam manual. (Luff, 2000)

Summary and recommendations

There are a number of at best questionable, at worst flawed assumptions that many manufacturers have, perhaps unknowingly, made in the design of their MPWTS. Oxfam recognises that it is important to consider the following critical points:

1. A broader view of health risks in the environments encountered post crisis does not warrant the focus on attaining very high standards of water purity.
2. An emphasis on the availability of systems that can be deployed in a couple of hours (as opposed to use of a more durable/sustainable systems which take a little longer to set up) seldom has a significant positive health impact.
3. Water may need to be treated that is highly turbid and

out of the effective functioning range of many MPWTS, potentially rendering expensive investments as worthless.

4. That communities' don't need expensive investment choices made on their behalf, especially where these prove to be unsustainable.

In seeking to address major limitations identified, Oxfam has adopted an alternative approach to water treatment. The development of the systems in Oxfam tanks provides a versatility that is unmatched by any other emergency system available anywhere. The ability to successfully treat a range of water qualities through predetermined equipment selection is greatly enhanced because the technology choice is robust and tolerant of a wide range of raw water quality. Finally the development of this equipment has been undertaken based upon substantial real life experience and as a consequence more valid assumptions have been made in its design, specifically about water quality versus quantity and on the recognised need to be able deal with high-suspended solids loading. This experience means the equipment will be far more likely to deliver the needs of the community and often at a significantly lower cost.

While the choice of water supply systems are likely to be determined by communities in more stable long-term situations, the reality of crisis response is that choices are often made by relief agencies themselves on the communities' behalf. Thus the onus must be on the relief agencies to make wise choices, based upon reasonable assumptions, by seeking value for money and sustainability, factors which would surely have to be considered for development projects. While relief agency decision makers may not be sufficiently familiar with Oxfam technology choices to feel comfortable to use them, they must be sure that whatever choices they do make, are able to deliver water to affected communities on an ongoing basis in order to have the health impacts desired.

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