Problems of treatment process selection for relief agency water supplies in an emergency

Andre Steele and Brian Clarke

ABSTRACT

There is currently limited public information available concerning methods for the selection of appropriate water treatment technologies for application in acute phase emergency water and sanitation responses. Considering the number of available emergency water treatment and supply options, it is speculated that a framework methodology offering guidance in the form of a selection process would offer advantages. This process would relate a defined set of emergency factors to a selection of available water treatment and supply options, described by a basic, but complete, set of technical and operational characteristics. It is suggested that, whilst not a complete process, the proposed framework methodology is sufficient to lead to the identification and selection of appropriate options for deployment. Furthermore the support of critical decision making by a logical framework, could help shape and justify the actions of agencies and workers in the field.

Key words | emergency water supply, relief agency, water treatment selection

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INTRODUCTION

A humanitarian response will cover a number of different aspects, including water, sanitation, food, shelter and health. History records many past disasters and emergencies, which saw concerted humanitarian efforts by a variety of relief organisations. Together with medical assistance, it is often the water and sanitation, or 'watsan', aspect of a relief response that has the greatest impact on saving lives. The provision of drinking water can also be the most challenging aspect of a response, with no standard solution. The availability, quality and condition of water source and surrounding region will differ immensely from event to event, making it impracticable to provide a one-for-all solution

Water provision in the developed nations is an established industry meeting demanding standards. There is, as a result, a wealth of information on the theory, operation and management of water treatment and supply in the industrialised world. Much of this relates directly to large scale works providing upwards of 200 litres/head/day to communities of anything from thousands to millions. Little of this knowledge is directly applicable in the acute phase of an emergency, where a large quantity of relatively good water is more important than a small quantity of high quality water (Luff 2004). The Sphere Project for minimum standards in core areas in emergency situations, states that the water supplied should be at least 15 litres/head/day with a turbidity of less than 5 NTU and 0 coliform per 100 ml (Sphere 2004). The ranked criteria for provision of water in an emergency situation, is effectively summarised by Clarke *et al.* (2004) as:

(a) Coverage: Available today for all
(b) Quantity: meeting a minimum daily demand
(c) Continuity: available all day, everyday
(d) (i) Quality: Meet Sphere or other required standards, (ii) Cost: affordable treatment and supply options, particularly if system is to be transferred to community control.

Meeting these criteria may be difficult, especially when considering the background of uncertainty in which the responding agency will be required to work. There has been a recent increase in the use of compact, rapid deployment,

doi: 10.2166/wh.2008.059

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water treatment kits by relief agencies. These units, initially developed by relief agencies, but later by private companies, now offer a wide range of treatment options specifically designed for rapid field deployment. Examples of available systems and their recent use includes:

- Oxfam Field Upflow Clarifier, developed by Oxfam saw most recent use in Aceh, Indonesia (Figure 1) during the 2004 Tsunami response by Oxfam (Fredlund 2005).
- LMS OX E1 Pressure Filter was developed by LMS France. It was used during a recent outbreak of cholera in Ethiopia by UNICEF (Figure 2) (Gossa & Polo 2007).
- The Sky Juice Sky Hydrant^{TM} is a microfiltration system for small scale water production. It was used by Oxfam in Sri Lanka during the 2004 Tsunami response (Bastable 2007).
- Stella Meta Pre-coat Filters (Figure 3) were used by a Thameswater volunteer team in Aceh during the 2004 Tsunami response (Nicholl 2006).
- Batch clarification is a standard process which has been used by many agencies (Dorea *et al.* 2004).

However, despite an extensive range of options, there exists very little published information on these systems, beyond the manufacturer's documentation. Obtaining performance data on field use of specific treatment solutions is particularly difficult as field monitoring is relatively rare and very little is documented (Clarke *et al.* 2004). Considering this, it is therefore not surprising that a structured method for selecting technically appropriate treatment systems for emergency application is not available at this time.

Figure 1 | Construction of the Oxfam Upflow Clarifier in Lamno, Aceh.

Figure 2 | LMS OX E1-2P Pressure filter system operating in Hassahiro, Ethiopia.

Oxfam, Medecins Sans Frontieres (MSF) Belgium, International Federation of the Red Cross (IFRC) and most other major agencies working in water and sanitation for humanitarian relief operations have staff with the knowledge and experience needed to select an appropriate solution. MSF Spain, aims to establish a team of experts in the field immediately post-event, who are then capable of

Figure 3 | Stella Meta Pre-Coat Filters in Operation in Aceh.

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choosing an appropriate solution (Weatherill & Dorion 2007). However, the required knowledge invariably resides with the individual, resulting in limited guidance relating to system selection being available in published form. The United Nations High Commission for Refugees (UNHCR), limits its guidance to "as a rule, technology and equipment for water provision should be simple, reliable, appropriate and familiar to the country" (UNHCR 1995). Davis & Lambert (2002) go a step further in 'Engineering in Emergencies' by providing information on treatment options for different water sources, but limit the options to a few classic solutions, including slow sand filtration, chemically assisted sedimentation and roughing filters. Adams (1999) suggests in *Managing Water Supply and Sanitation in Emergencies* that the criteria for the ideal technology should include reliability, tolerance to a variety of feed waters and operating conditions, cheap cost and effective performance. Furthermore, it should require minimal skill and knowledge to run and allow easy monitoring. Luff (2004) concludes that the critical points to note with treatment solutions, and more specifically Mobile Package Water Treatment Systems (MPWTS), is rapid deployment, the ability to deal with highly turbid water and low capital and operational costs. This last point is emphasised if the system is to be given to the community post-emergency .

Though none of these suggest a selection process, these authors do provide a basis for establishing a criteria set which describes the technical and operational characteristics of a treatment system. The combination of the UNHCR Handbook and work by Adams (1999) indicates that any solution should be simple, reliable, tolerant of any feed water quality, tolerant of operating conditions, cheap, effective, require minimal skill and knowledge and be familiar to the region of application.

This leads to a two-fold hypothesis. Firstly that there is a broadly accepted set of characteristics by which the available water treatment options for acute phase emergency deployment can be compared and contrasted. Secondly, that there is a set of factors, which immediately post-event, could be used to identify and select an appropriate treatment solution or solutions.

If it follows that there is a most appropriate treatment solution for every application, there must first be a set of influencing factors by which an emergency can be described. Whilst there will be any number of factors affecting the overall response, the salient information required for water treatment selection should be more definable. A set of "influencing factors" were developed, based on the state of knowledge required for technology selection. It is proposed then that the set of influencing factors should be:

- Nature of the emergency
  - The event
  - Affected population
  - Living conditions
  - Water demand
  - Access and communication
  - In-country human resources
  - In-country plant and material availability
  - Security in region
- The water source
  - Availability of water in region
  - Nature of the water source
  - Location of water source
  - Quality

Ideally, decisions would be made under a complete state of knowledge, indicating that all of the above factors are accounted for, providing sufficient knowledge to make a logical decision as to an appropriate treatment solution. It is recognised, however, that collecting the data for such a state of knowledge in the early stages of a response is unlikely. It is acknowledged, therefore, that decisions may need to be made prior to an agency acquiring a complete knowledge base.

To lead on from this to a selection procedure, a description of the solution is needed. The development of a criteria set detailing the characteristics of the available options should list the advantages and disadvantages of any one treatment system or process. This information can lead to a conclusion as to the applicability of any one solution, given a particular event described by the given state of knowledge. It is suggested that this criteria set should cover both the operational aspects as well as the technical and performance related characteristics. Thus it should include:

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- Potential Throughput: the capacity at which the system can be operated.
- Potential Quality Improvement: the improvement in quality achievable by a system operated within its limits.
- Potential Reliability: the operational reliability and robustness of the solution as a whole.
- Potential Maintenance Level: the required maintenance under normal operating conditions.
- Rate and Ease of Deployment: the speed and ease at which a solution can be established and started in the field.
- Capital & Operational Cost: the cost of purchase and operation of the system.
- System Complexity: the complexity of the system and the ease with which it can be maintained in the field.
- Required Operator Skill: the required capability of the operator.
- Required Supervisor/Operator Knowledge: the required theory the operator or supervisor needs for daily operation.
- Required Consumables: the rate and nature of required consumables.

It is suggested that the combined influencing factors and the technology characteristics, could provide a framework for a process for emergency water treatment selection. It is believed that each factor will influence the selection, though the extent of that influence may vary from event to event. The trend, however, is towards an appropriate selection based on the optimum technical and operation characteristics dependant on the present factors (see Figure 4). It is worth noting that a structured data recording practice would also provide a feedback loop allowing the optimisation of the selection procedure for future applications.

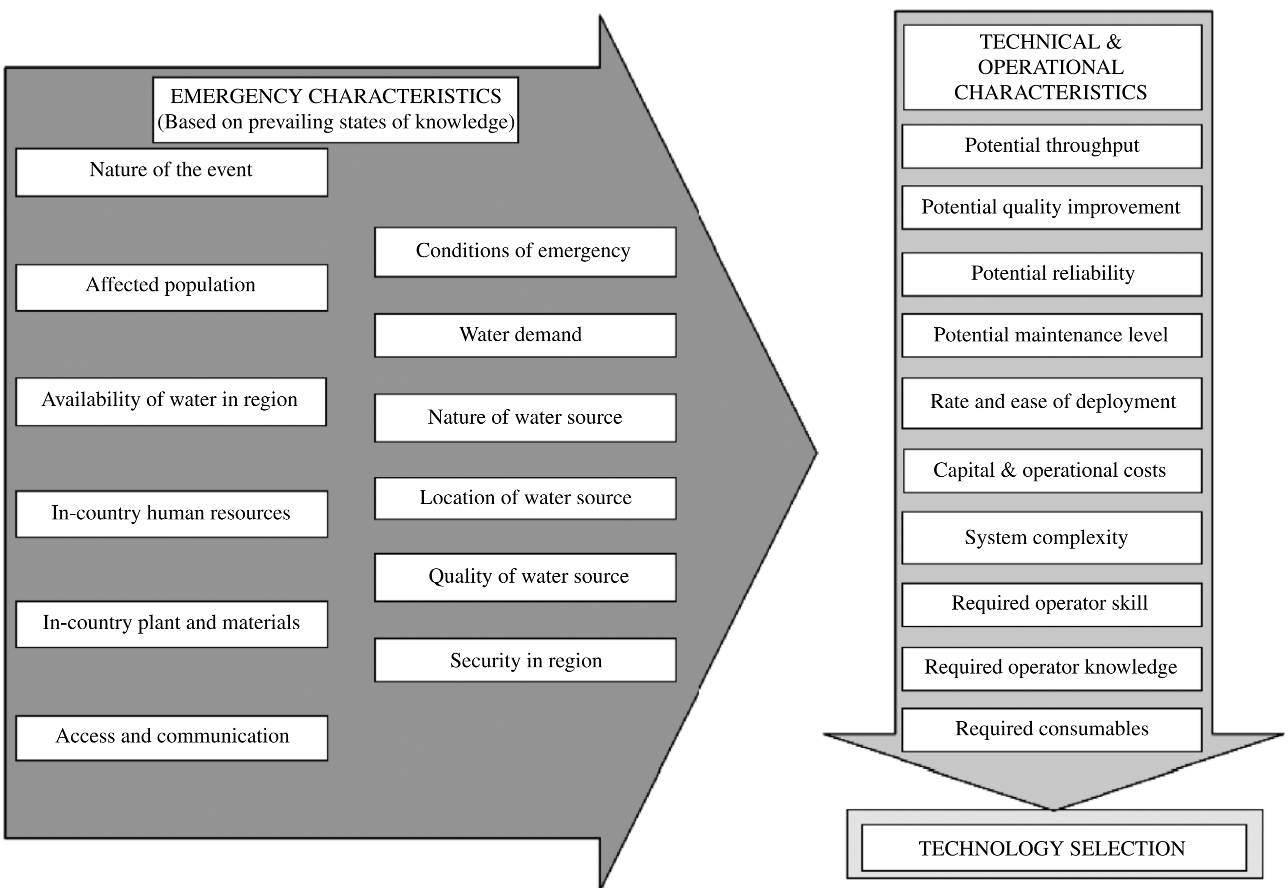

Figure 4 | Process of selection of water treatment system in acute phase emergency application.

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It is recognised that there could be more influencing factors, depending on the agency involved and the political status and policies of the region or country.

In the acute phase of a response, the agency will make decisions on the behalf of the community (Luff 2004). These decisions will be supported by a knowledge base developed primarily through experience, which can lead to the replication of responses in widely varying applications; "if it worked before it will now" (Weatherill & Dorion 2007). Consequently, the current method of selection is through an intuitive process on the part of the agency, and may not, therefore, be entirely logical. Some agencies have developed personal rapid deployment kits, or have preferred treatment solutions, specifically for emergency applications. MSF Belgium developed an assisted direct rapid sand filtration system, capable of treating up to $10m^3$/hr, using the coagulant ferric chloride (van den Noortgate & Goessens 2003). The system has seen much use in the field including MSF missions in Rwanda, Guinea Conakry and long-term operation in Sierra Leone, where the system has been operated for approximately 10 years (van den Noortgate 2005). It follows then that emergencies in which MSF-Belgium respond may very well see this system deployed. There is therefore an influence from the involved agency. An agency will build on its own experiences and knowledge and act within the limits of its mandate. It will do so in a manner that is within its capacity and with what it deems to be an appropriate solution. This response may be entirely dependent on the experience of the field operatives, who may or may not act within a logical framework, but rather intuition based on experience. The adoption of a solution simply because it is known by the responding agency, does not necessarily lead to the conclusion that it is an appropriate system for the application. It is suggested then, that the experience and capabilities of the responding agency will influence decisions throughout their presence in the region.

It is also possible that a local and national influence will affect the selection of the treatment solution. In Northern Uganda, the government was directly responsible for the displacement and housing of up to 2 million people. By all

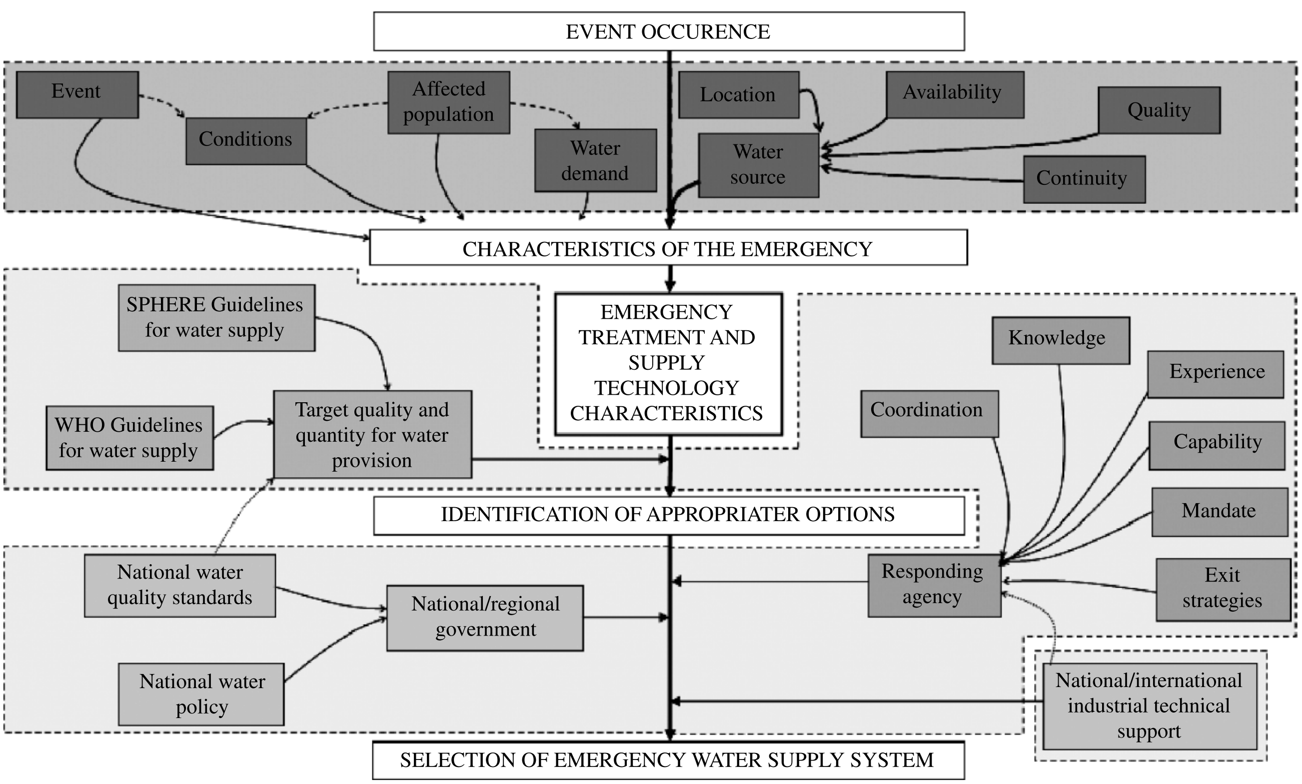

Figure 5 | Influence of conditions in an emergency response on the selection of water treatment options.

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accounts the internally displaced people (IDP) camps which formed were poorly planned with few facilities. With a small number of agencies operating in the area, it was the responsibility of the national and local government to provide water, which did not appear to be successful. The mean quantity of water per head per day provided in the Kitgum district was 9.7 litres, with an average queuing time of 3.6 hours (Checchi 2006). More recently, with the announcement by President Museveni, that all IDPs will return to their villages, by way of temporary transitory camps, it fell to the Ugandan military to select the site of these transitory camps. Reportedly these were often selected with defence in mind, and often no water source was available within walking distance (Paul 2006). Both these points serve to illustrate the potential influence of local government on the emergency water supply. There are therefore external factors, from national and regional government, and possible external commercial or political influences, which could affect the final selection of a treatment solution. Conversely there may be no regional or national government, which in itself brings in a new set of considerations. These factors are not necessarily quantifiable and can vary with agency, event, location and time. They bring an increased degree of uncertainty into the proposed selection process. It is suggested that, where possible, limited consideration is given to their influence until an appropriate treatment solution or solutions have been identified. Final selection can then take them into account. Figure 5 attempts to illustrate the suggested influence of factors through the selection process.

CONCLUSION

There exists a large number of water treatment kits specifically designed for rapid deployment in emergency situations. It is apparent also that there is little or no guidance available to suggest which option is the most appropriate technology for any one application. It is suggested that a framework methodology is needed to support logical decision making and enhance the current intuitive process of selection based on the experience and knowledge of the agency.

Considering then that there will be an appropriate selection, or selections, for each situation, it follows that a set of influencing emergency factors is needed to relate the application to the required technical and operational characteristics. If this same set of characteristics is then used to describe the available options, a process exists by which an appropriate system can be identified. It is acknowledged that these factors represent an ideal state of knowledge, and that it may be necessary to make decisions with incomplete knowledge of the overall prevailing conditions.

It is known that there will be further factors beyond those that are described as needed for selection purposes. However, these are for the most part unquantifiable, as they rely greatly on the human factor. It is believed that they are not essential in the selection process, and could be factored in after suitable systems have been identified. It may then be possible for a final refinement of the process in which an appropriate system can be selected, maximising the potential for successful water provision in the acute phase response.

A basic concept for a selection process has been presented. However, there is currently insufficient information on the influence of particular factors and the technical and operational description of the available units. It is suggested that a detailed and inclusive, technical and operational study involving a range of agencies would need to be carried out to develop an effective system selection methodology. This would cover both the description of currently available systems and the collection of information relating to acute phase emergency situations.

REFERENCES

Adams, J. 1999 *Managing Water Supply and Sanitation in Emergencies*. Oxfam, Oxford, UK.

Bastable, A. 2007 *Personal Communication*. Oxfam, Oxford, UK, 15/03/2007.

Checchi, F. 2006 Humanitarian Interventions in Northern Uganda: based on what evidence? *Humanitarian Exchange* **36**, 7–11.

Clarke, B., Crompton, J. & Luff, R. 2004 A physico-chemical water treatment system for relief agencies. *Proc.Inst. Civil Eng.Water Manage.* **157**(4), 211–216.

Davis, J. & Lambert, R. 2002 *Engineering in Emergencies: A Practical Guide for Relief Workers*. ITDG Publishing, Bourton-on-Dunsmore, UK.

Dorea, C., Bertrand, S. & Clarke, B. 2004 Particle separation options for emergency water treatment. *Wat. Sci. Technol.* **53**(7), 253–260.

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Fredlund, B. 2005 *The Performance of the Oxfam Upflow Clarifier in Response to the 2004 Tsunami in Aceh, Indonesia*. M.S.c. Disseration, University of Surrey, UK.

Gossa, T. & Polo, F. 2007 *Challenges and Lessons Learnt in Supporting a Decentralised Approach*. Emergency Environmental Health Forum 2007, Delft, Netherlands, 3-4th May 2007.

Luff, R. 2004 *Paying too much for Purity? Development of more appropriate emergency water treatment methods*. People-Centred Approaches to Water and Environmental Sanitation, WEDC International Conference, Vientiane, Lao PDR.

Nicholl, D. 2006 *Indonesian Tsunami – Operational Issues*. Disaster Relief – Planning and Providing Emergency Water and Sanitation Services, Nottingham, UK, 25–26 January 2006.

Paul, D. 2006 Heading home? Protection and return in Northern Uganda. *Humanit* **36**, 4–7.

Sphere 2004 *The Sphere Project Humanitarian Charter and Minimum Standards in Disaster Response*. Available online: http://www.sphereproject.org/.

UNHCR 1995 *Water Manual for Refugee Situations*. United Nations High Commission for Refugees, Washington D.C. USA.

van den Noortgate, J. 2005 *Personal Communication*. Centre for Environmental Health Engineering, University of Surrey, Guildford, UK.

van den Noortgate, J. & Goessens, E. 2003 *Water Treatment Unit: Assisted Direct Rapid Sand Filtration Operators Manual*. Medecins Sans Frontieres, Brussels, Belgium.

Weatherill, D. & Dorion, C. 2007 *Personal Communication, 20/03/2007*. Medicins Sans Frontieres, Barcelona, Spain.

First received 11 May 2007; accepted in revised form 9 September 2007. Available online March 2008

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