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Coagulant-based emergency water treatment

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Abstract

Emergency water treatment approaches relying on coagulation vary from centralised modular and portable ‘‘kits’’ to ‘‘point-of-use’’ or ‘‘household’’ interventions. Typical coagulation practice in emergencies is reviewed in view of field constraints (e.g. equipment and resources) and contrasted with underlying theory and conventional water treatment procedures. Examples of coagulation in emergencies are also presented based on documented field experiences alongside the discussion of other relevant issues such as process control, sludge production and management, ease of use, and aluminium coagulant residuals in finished waters.

Keywords: Aluminium sulfate; Coagulation; Disaster; Emergency; Flocculation; Water treatment

1. Introduction

An emergency is a ‘‘situation arising in the aftermath of a disaster’’, which can result in ‘‘a serious disruption of society, involving widespread human suffering and physical loss or damage, and stretches the community’s normal coping mechanisms to a breaking point’’ [1]. Emergency relief efforts from aid organisations are necessary when the response capacity of local authorities is insufficient. From a public health point of view the (re-)establishment of a safe water supply is one of the three main interventions, together with hygiene promotion and sanitation. Such actions will reduce the exposure of the affected population to health risks and prevent the spread of water- and excreta-related diseases, as classified by Mara and Feachem [2].

The transmission of water-related diseases in emergencies is as much likely to the lack of sufficient quantities for personal and domestic hygiene as to contaminated water sources [3]. Hence, the quantity of water supplied is prioritised over the quality [4]. However, this is done without neglecting the importance of a supply that is free of pathogens and aesthetically pleasing. In other words, according to Luff [5], ‘‘a larger quantity of relatively good quality water is better than a small quantity of very high quality water’’. Minimum levels of water quantity and quality in a humanitarian response (Table 1) have been proposed [3]. Water quality should always be improved, but it does not change as much as the quantity requirements. That is, as emergencies shift from immediate-,

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Table 1
Selected sphere standards water supply [3].

Standard	Key indicators (abridged)
1 – Access and water quantity	• On average at least 15 L/head/day for drinking, cooking and personal hygiene • Maximum distance to the nearest water point from the household is 500 m • Queuing time at a water source is less than 15 min • No more than 3 min to fill a 20 L container • Water sources and systems are maintained, delivering adequate quantities on a consistent or regular basis
2 – Water quality	• A sanitary survey indicates a low risk of faecal pollution • No faecal coliforms per 100 mL at the point of delivery • Protected or treated source used in preference to other available sources • Steps are taken to minimise post-delivery contamination • Disinfection with free Cl_2 residual at tap of 0.5 mg/L and turbidity <5 NTU • No negative health effect is detected due to short-term use of water contaminated by chemical (including treatment chemicals) or radiological sources, and assessment shows no significant probability of such an effect

late-, and post-emergency phase, water quantities also change. Initially, water supply ensures the survival of the victims catering their very basic needs. As water sources are developed, larger volumes can be supplied for other purposes (e.g. bathing, laundry, and livestock). Finally, more durable/sustainable water supplies are sought during the rehabilitation work involved in post-emergency relief.

When surface waters are used as emergency sources they must undergo treatment which essentially involves turbidity reduction to facilitate disinfection; typically achieved by coagulation. Although it is relatively well established as a treatment process for conventional municipal drinking water purification plants, its use in emergencies must be adapted due to practical constraints (e.g. instrumentation and resources). This paper provides an overview of coagulation as an emergency treatment process in view of current practice and other issues arising from field experience and discussions within humanitarian aid agencies, such as coagulant residuals and sludge disposal.

2. Coagulation

Conventional water purification plants utilise coagulants primarily for turbidity reductions and removal of natural organic matter. The latter are removed as precursors to potentially carcinogenic disinfection by-products. Furthermore, coagulants are capable of achieving a considerable reduction of microbiological contamination. Yet, in emergencies, coagulants are used primarily for the reduction of turbidity and to facilitate chlorination. This is due to the minimum emergency water quality requirements (Table 1) and to the basic analytical field capacity available in emergencies, such as ‘‘DelAgua kits’’ [6]. Such water quality testing kits are capable of making determinations of four critical drinking water quality parameters: thermotolerant (faecal) coliforms, turbidity, pH, and free/total residual chlorine. As such, any additional contaminant removal that may occur comes as a secondary benefit, as they cannot be measured.

Aluminium sulfate, or alum, is the most common coagulant used in emergencies, as it can be procured locally at a relatively cheap price in most parts of the world. Optimum turbidity reductions with aluminium sulfate can normally achieved within the pH range of 6.0–7.5 [7]. The minimum solubility of aluminium (Fig. 1) usually lies within this range (i.e. pH 6.0–7.0) [8], which is important to consider during the control of aluminium residuals. When alum is added to