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DELIVERING WATER, SANITATION AND HYGIENE SERVICES
IN AN UNCERTAIN ENVIRONMENT

Inclined plate settling for emergency water treatment

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Adequate water supply is a public health intervention aimed at preventing diarrhoeal diseases in relief operations. Based on humanitarian water treatment objectives in which supplied water quantities should be prioritised (whilst safeguarding minimum quality standards) an inclined plate settler (IPS) was tested. Preliminary testing revealed that the IPS was capable of stable turbidity reductions at several tested conditions, but further optimisation was required to reach the treatment objectives with regards to turbidity reductions (i.e. 5 NTU). The simplicity and relative low-cost of manufacturing makes this process a potentially cost-effective solution for emergency water treatment.

Introduction

Provision of adequate water supply together with sanitation, and hygiene promotion form a vital three-pronged public health intervention approach aimed at preventing infectious water- and excreta-related (diarrhoeal) diseases (Mara and Feachem 1999). Such illnesses are one of the major contributors to the overall morbidity and mortality rates during a humanitarian crisis (Connolly et al. 2004; Waring and Brown 2005). In order to meet the public health intervention aim of prevention/reduction or diarrhoeal diseases during emergencies with regards to water supply, the recommended priority (WHO, 2005; The Sphere Project 2011) is for larger quantities of water (i.e. for personal hygiene) of "safe" quality (no thermotolerant coliforms per 100 mL, 0.5 mg/L of free chlorine residual, and turbidity < 5 nephelometric turbidity units – NTUs). In other words, a larger quantity of relatively good (safe) quality water is better than a small quantity of very high quality water.

Field experience in humanitarian crises has shown that of the commercially-available treatment "kits", many are designed to yield only small quantities of highly purified water (Luff and Dorea 2012). By placing "treated water quality" (i.e. before chlorination) at a premium, many such kits utilise processes (e.g. reverse osmosis, activated carbon) that compromise production yields if favour complex and expensive systems with high degrees of (physical and chemical) purity; which is typically not relevant (i.e. not an acute risk) to most humanitarian contexts (House and Reed 2004). Thus, the dual role these kits should fulfil (i.e. provision of water of safe quality for hydration and in adequate volumes support hygiene practices) is compromised. Moreover, many such technologies are often vulnerable to waters of high turbidities (as is typically encountered), which can further affect their production yields (Dorea et al. 2006). In most cases, recommended microbiological quality is attained by final chlorination, regardless of the upstream treatment system.

From the perspective of these field-driven requirements, a new humanitarian emergency water treatment kit based on lamella plate settling has been developed and is reported here.

Materials and methods

An inclined plate settler (IPS) prototype was built in mild steel (Photograph 1 and 2) for a maximum design flow rate of 3 m3/h. 36 plastic plates of 0.75 x 0.80 m were fitted at an angle of 55°; providing a design maximum surface loading rate of 0.24 m3/m2/h. Testing facilities consisted of a 11 m3 tank in which a kaolin clay slurry was mixed to desired the test water turbidity. Pre-conditioning of the raw water to be treated was achieved through locally-sourced aluminium sulfate (i.e. alum) coagulation by suction side dosing (i.e. a coagulant vessel tapping into the suction line of a pump), which alongside the modified field jar-test for coagulant dose determination is described elsewhere (Dorea 2009). Mixing of the coagulant was promoted through the pump impeller and a 60 m length of 3" coiled layflat hose; which was then connected to the IPS inlet. Typically, terminal disinfection would be practiced by chlorination of the IPS effluent so as to guarantee the potability of the treated water with regards to microbial water quality. During these trials, such step was not undertaken as the main objective was to assess the IPS performance with regards to turbidity reductions. This parameter is thought to be a limiting factor in the performance of many emergency water treatment kits (Luff 2004; Dorea et al. 2006).

Photograph 1. IPS testing facilities in Pune

Photograph 2. Top view of IPS

Results

Preliminary testing and emergency water treatment kit development work was carried out in India. An experimental testing rig was setup allowing for synthetic turbidities in low (≈ 50 NTU), medium (≈ 100 NTU), and high (> 200 NTU) ranges to be tested. Results demonstrated that turbidity reductions close to target values could be achieved with the system running (with trial runs of up to 4 hours) at flow rates of up to 3 m3/h at all turbidity levels. Further optimisation of treatment process with an additional flocculation step further improved turbidity reductions. Also, test runs revealed that the system was robust in handling variations in turbidities and flow rates. Together with a final chlorination step this lamella plate settler could produce water in accordance to quality and quantity recommendations in humanitarian contexts (The Sphere Project) without the limitation of filtration-based systems (i.e. high turbidity vulnerabilities); which coupled with a relatively low production cost and simplicity could make this a truly cost-effective system.

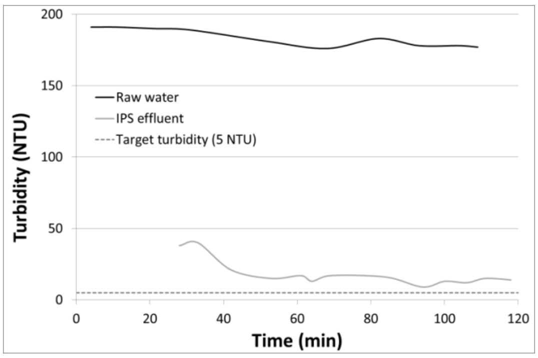

Figure 1. Treatment run turbidity profile

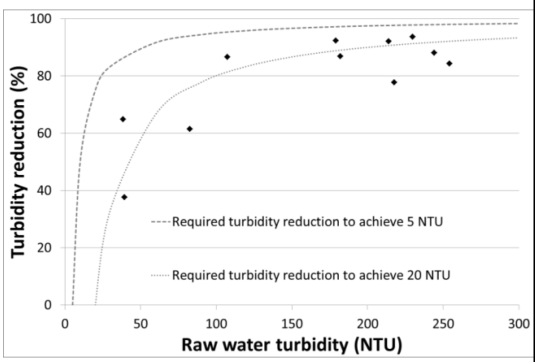

Figure 2. Preliminary testing summary

Despite reductions in flow rates and increases in alum doses achieved limited improvements with regards to final effluent turbidity. One possible explanation for this is that the lack of an adequate flocculation stage hindered the formation of readily settleable flocs. A 60 m length of 3” layflat hose was used to promote coagulant mixing based on other emergency water treatment system designs. However, the hydraulic regime (i.e. turbulent flow) and mixing times (i.e. < 2 minutes) resemble more a rapid mixing stage.

Although there is scope for further testing and process optimisation, the IPS prototype has the potential to serve as an emergency drinking water treatment technology. Given the capacity of turbidity reductions of inclined plate settling, such a process has also the potential to increase the cost-effectiveness of emergency water treatment solutions. This is based on humanitarian water treatment objectives (The Sphere Project 2011) in which supplied water quantities should be prioritised (whilst safeguarding minimum quality standards that can be achieved with terminal chlorination of the IPS effluent). Considering such objectives, the capital cost of a system normalised by its production yield has been recently described as a gauge of an emergency water treatment system’s cost-effectiveness (Dorea 2012). Albeit a simple metric, it could provide a first screening of potential technologies that are fit-for-purpose in relief contexts. Other, factors such as running costs, emergency setting (e.g. dispersed population), required expertise and maintenance, as well as agency preference will also be factors to be considered in the selection of a treatment system.

Extrapolating from the IPS prototype costs, the described process, with a capital cost per yield of approximately 1300 USD/m3/h, would be ranked amongst other cost-effective systems. The capital cost per yield of other commercially-available systems can vary by several orders of magnitude (e.g. 1600 to 11400 USD/m3/h). Typically, the more expensive systems are ones based on designs that prioritise water quality and require processes (e.g. granular media and membrane filtration) that can be vulnerable to high turbidity levels typically encountered in emergency situations (Dorea et al 2006). However, the demonstrated capacity of the IPS to reduce such particulate loadings could be a way to increase the effectiveness of other systems by providing a pre-treatment.

Conclusions

Preliminary testing revealed that the IPS was capable of stable turbidity reductions at several tested conditions, but further optimisation was required to reach the treatment objectives with regards to turbidity reductions (i.e. 5 NTU). The simplicity and relative low-cost of manufacturing makes this process a potentially cost-effective solution for emergency water treatment.

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