Performance of a water clarifier in Gonaives, Haiti

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Water drawn from rivers under emergency conditions often suffers from a high turbidity. This article describes how a water clarifier was tested in Haiti, demonstrating significant improvements in water quality over an extended period of time and at a relatively high production rate.

Although sand filtration systems are efficient in removing particulates, the effectiveness of such approaches to emergency water treatment may be compromised with high raw-water turbidity loadings. This article looks at the performance of an upflow clarifier recently deployed to Haiti.

The Oxfam Field Upflow Clarifier is a coagulant-based emergency water treatment system developed by the University of Surrey and Oxfam in a jointly funded project by DFID (Department for International Development) and Oxfam. Basically, alum is added through a suction side doser assembly originally developed by MSF. The suction of the pump is the driving force of the doser. The pump impeller provides the rapid mixing. The flow is then split into two lengths of layflat hose which are coiled around the standard 11 000 litre (T11) tank into which the clarifier PVC funnel is fitted. The hoses act as flocculators, providing the necessary slow mixing conditions.

Once entering the bottom of the T11 tank, the flow makes its way upwards through the base of the funnel. As the cross-sectional area of the funnel increases, the velocity of the fluid decreases. At a certain height the upward forces acting on the floc balance out the gravitational forces. In this region, floc remains stationary and a blanket forms (Figure 1), thickening with time. Any floc passing the blanket is caught in a fabric polishing filter placed at the top of the clarifier.

More detailed information on the clarifier's construction, testing and operation is available elsewhere.[1]

Hurricane Jeanne

During the night of 18 September 2004, tropical storm Jeanne led to heavy rainfalls over regions of Haiti. The country's third largest city, Gonaives (population 200 000), experienced significant flooding. Reportedly, flood-water levels were 1.80 to 2.70 m high, leaving 80 per cent of households completely flooded. The affected population was in urgent need of drinking water, food, hygiene kits, shelter and medical aid.

The distribution of bottled water, as an initial response, proved to be difficult, due to security issues. Upon arrival of the water storage and treatment kits, Oxfam's WATSAN team concentrated on setting up storage tanks and tapstands, setting up the clarifier and rehabilitating an irrigation well (having a yield of 90 litres/s, 324 m^3/h).

Oxfam's Field Upflow Clarifier, tested in Gonaives

Other humanitarian organizations already active in the area were treating river water and a multi-agency effort was made to distribute drinking water by tanker trucks to key locations.

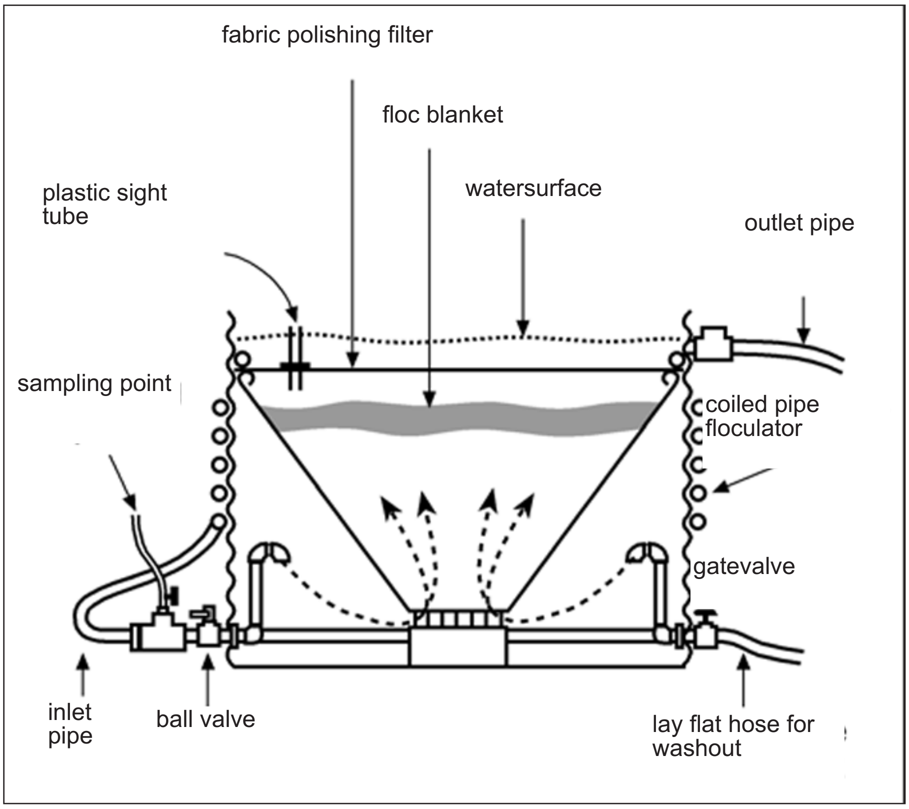


Figure 1 The operation of the water clarifier

Suction side-dosing arrangement

However, drinking water production had still not met the demands of the emergency. With an operational clarifier it was hoped to add another 8 to 10 m^3/h of drinking water.

Regrettably, the installation of the clarifier was severely delayed and eventually interrupted due to security conditions. Fortunately, the restoration of the well was a success. The yield of the well was sufficient to meet the demands of the emergency and the quality of the groundwater was such that it only required final disinfection. Although the clarifier was no longer needed, its construction was completed and a trial programme was performed in January 2005 to evaluate its performance. The site for the clarifier was at Pont Gaudin on the banks of the La Quinte River.

Test programme

Frequently in October 2004 the turbidity of the river could not be measured with a turbidimeter that had a detection limit of 1000 NTU (Nephelometric Turbidity Units). In January 2005 the turbidity of the river was usually only 10–20 NTU. To make the trials more challenging for the clarifier, a small dam was constructed across a section of the river. With a lightweight petrol pump and a 2-inch (5 cm) hose, the dammed water was circulated, resuspending the sediment and increasing the turbidity.

The clarifier was tested for five runs, during which time the polishing fabric was washed once. Cleaning was done by laying the fabric against a wall and scrubbing it with a broom and water. A high-pressure jet of water was recommended for this procedure, but none was available. The trials' operational conditions are summarized in Table 1.

Initially, a simplified jar test was done to estimate the optimum dose.[2] However, the objective of this test is to mimic the mixing times and energy gradients of the relevant process. As this is not achieved with the simplified jar test, one can only assume that the optimum dose is an estimate. Hence, during several runs the same alum dose was applied at different flow rates.

Turbidity was measured every 30 minutes using a HACH(r) 2100 P portable turbidimeter.[3] The thermotolerant faecal coliform group was used as an indicator of faecal contamination. Duplicate tests were completed, using the membrane filtration method.[4] Culture medium, sample bottles, and petri dishes were all sterilized by placing the items in a pressure cooker for at least 15 minutes under full pressure; pH and headloss through the fabric were also determined. At the outlet of the clarifier a 200-litre plastic barrel and stopwatch were used to calculate the flow rates.

Results

Table 2 summarizes the results from the clarifier trials. Runs 1 and 2 were of short duration, due to a problem with air leaks on the suction side of the pump. As such, these first two runs were not sampled for pH or faecal coliforms. The pH of raw water and clarifier effluent varied from 7.8 to 8.0 and 7.0 to 7.2 respectively. Reasonable improvements were made, even without the fabric filter. Runs 3 to 5 all lasted six hours. Impressive turbidity reductions were achieved in all three runs. The different loading rates applied did not seem to affect the clarifier's performance.

All three runs presented similar thermotolerant faecal coliform removal efficiencies, ranging from 98.0 to 98.8 per cent reduction, producing water with 19 to 32 cfu/100 ml from a moderately polluted source. Importantly, it should be noted that the clarifier effluent was below 5 NTU (and less than 1 NTU for a considerable time) for the last three runs. The significance of this is that with terminal disinfection, the clarifier could produce a safe and wholesome water with respect to microbiological contamination treatable by chlorination.

Table 1 Operational conditions of clarifier runs

Run no.	Flow rate (litre/h)	Alum dose (mg/litre of alum)	Observations
1	10 240	50	Tested without fabric
2	9840	60	
3	9640	40	
4	6400	40	Fabric washed at end of run
5	7680	40	

Final comments

These field trials demonstrated that the clarifier was capable of producing water of good quality (both aesthetically and microbiologically) at relatively high flow rates, indicating that a production rate of 9000 litres/h is achievable. Hence, one unit working 12 hours/day would be capable of producing 108 000 litres, which if distributed at 10 litres per person caters for the needs of 10 800 people in, say, the initial phase of a crisis. Obviously, the number of units and daily working hours is case dependent, but this system has been previously tested in overnight runs with satisfactory results.[5] The only 'down time' would be during the changing of the fabric (10 to 20 minutes) or altering of pumps if a long working hour regime is adopted.

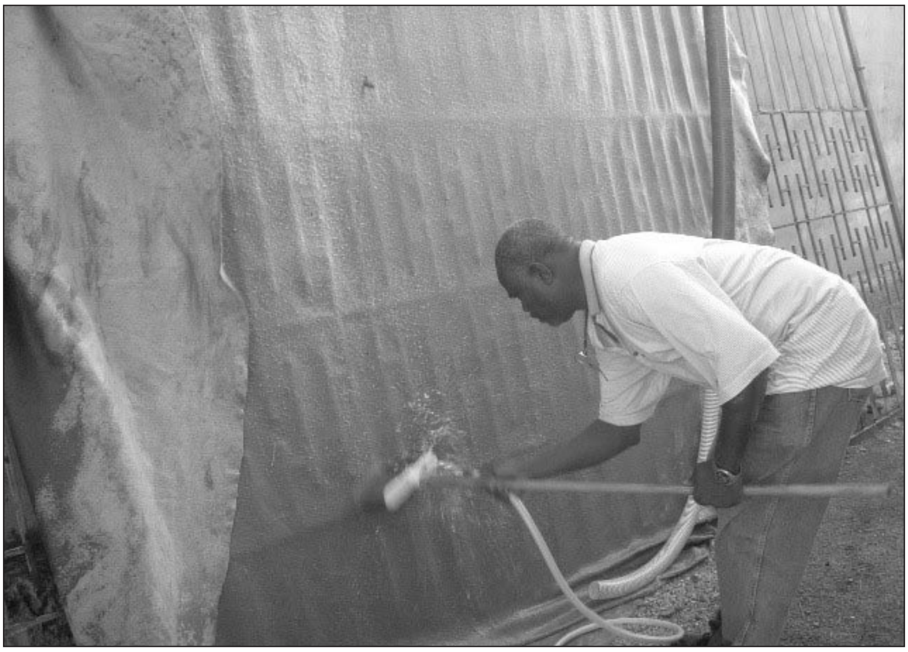
The clarifier can be constructed by three to four people – as many as the erection of the conventional T11 tank. During these trials a three-man team ran the system, one being a guard with no technical background. Yet, once the system was running, the technically unqualified team member on his own could make simple adjustments as necessary (i.e. doser flow control) in accordance with instructions.

Table 2 Summary of results for clarifier evaluation

Run no. (cm)	Duration (h)	Turbidity (NTU)			Faecal coliforms (cfu/100 ml)			Headloss
		Raw water (mean)	Effluent (mean)	Reduction (%)	Raw water (mean)	Effluent (mean)	Reduction (%)	
1	1.5	90.0	19.5	78.3	not tested	not tested	–	0
2	1.0	142	5.11	96.4	not tested	not tested	–	0
3	6.0	104	1.54	98.5	1780	26	98.5	4
4	6.0	57.3	0.82	98.6	1510	19	98.8	8
5	6.0	59.7	1.35	97.7	1640	32	98.0	4

Normally the clarifier can be constructed in one day. Although this was not possible in Haiti due to the security constraints, it was achieved when a clarifier unit was deployed to Meulaboh (Indonesia, 200 km from Banda Aceh) in January 2005 in response to the *tsunami* crisis.[6] In May 2005, the authors visited this unit and conducted training with local staff to optimize its performance. Also in Indonesia (Lamno, 70 km south of Banda Aceh), the authors installed another clarifier, as the pre-coat (diatomaceous earth) filters that were being used had their filtration runs shortened when the River Inong's turbidity increased; this was occurring more frequently with the coming of the monsoon rains. Both units in Indonesia were able to reduce raw water turbidities from 10–300 NTU to below 5 NTU.

In general the literature available on the performance of emergency water treatment kits is scarce. Hence the comparison of this unit with other types of kit is not possible. Moreover, each type of water treatment technology has its advantages and limitations possibly making each option more suitable for specific situations and emergency phases.[7]



Cleaning the polishing filter fabric

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