Simple improvements for emergency batch water treatment

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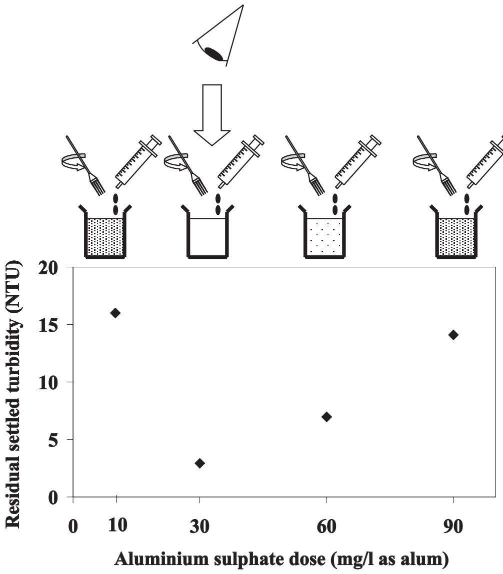
Batch water treatment consists of the intermittent use of settling tanks for water clarification, and is a common treatment practice during emergency relief efforts. This article presents simple improvements to coagulant dosing and water quality based on experience gained in the aftermath of the 2005 South Asian earthquake.

Emergency surface water treatment interventions can be divided into three categories: modular systems, mobile units, and point-of-use (household) approaches.[1] Of these, the simplest and one of the most frequently used techniques is that of coagulant-assisted batch clarification. Such a method typically utilizes tanks comprised of corrugated steel sheets that, bolted together, form a circular tank in which a synthetic butyl rubber liner is fitted (i.e. ‘Oxfam tanks’). Such tanks (11, 45, 70, and 95 m^3) have been developed by Oxfam and are assembled on site within a day by semi-skilled local labour. Other types of field-assembly tank are also available; consisting of a liner supported by a metal frame.

How is batch water treatment performed?

Batch-mode chemically assisted clarification is carried out in the storage tanks by adding the coagulant to the incoming water. In the field, doses are visually determined by simplified ‘visual’ jar-tests utilizing syringes for dosing, table forks or wrenches as stirrers, and plastic beakers (Figure 1). Different doses are added to each beaker, which are stirred and allowed to settle; subsequently the operator visually selects which beaker and corresponding ‘optimum’ dose resulted in the clearest water. In the example in Figure 1 the dose of 30 mg/l yielded the lowest turbidity. This is because of the coagulation chemistry of aluminium sulphate. Small amounts (e.g. 10 mg/l) may not be enough to achieve a good settling but too much (e.g. more than 60 mg/l) also can be detrimental by causing particles to restabilize (i.e. remain in suspension). It is worth noting that the objective of the jar-test is to mimic the mixing times and energy gradients achieved in the tanks. As this is not accurately achieved with the simplified jar test, one can only assume that the ‘optimum’ dose is at best a reasonable estimate.

‘Oxfam tanks’ of 95 and 70 m^3 capacity being utilized in Gonaives, Haiti



- **Raw water turbidity: 109 NTU;**
- **Fast mix: 30 seconds;**
- **Slow mix: 2 minutes;**
- **Optimum dose is visually estimated in the absence of a turbidimeter.**

Figure 1. Visual jar-test for coagulant dose determination.

Once the coagulant is added and the tank is full, the water is left to settle until the desired water quality is achieved. Sedimentation times can vary between 6 to 24 hours depending on water quality (i.e. level of turbidity), settling conditions (e.g. protection from wind), and volume of the tank (i.e. larger volumes require larger settling times). The settled water is then collected and disinfected prior to distribution. Despite limited process control, high turbidities in the hundreds can be reduced to what is considered acceptable by the Sphere Standards,[2] i.e. < 5 Nephelometric Turbidity Units (NTU).

South Asian earthquake

In the aftermath of the South Asian earthquake (8 October 2005) the water treatment and supply system of Gahri Doppata (AJK, Pakistan) were damaged. Before the water treatment plant could be rehabilitated, two emergency batch sedimentation tanks (70 m^3) were set up by Oxfam. Initially, these tanks were used for the water supply of the town and the internally displaced people (IDP) camps. As the rehabilitation of the water treatment plant progressed and the distribution system was improved, the emergency sedimentation tanks were used solely for the supply of IDP camps. During their service, several operational difficulties were faced (e.g. dissolution of rock alum for stock solution, occurrence of scum in the tanks, carryover of settled floc to disinfection tanks), which made attaining the desired turbidity reductions a challenge. These were overcome with some simple process upgrades using local resources.

Upgrades

Aluminium sulphate (alum) is the most widely available and commonly used coagulant that can come in many forms. Usually a stock solution is made by dissolving alum to a predetermined concentration. Dissolving alum is easiest when using its granular form, but alum is more often available in crystal or in rock form, which requires more time and mixing to dissolve. Such inconvenience was faced recently in Gahri Doppata. The difficulty was overcome by making an 'alum cage.' This was a basket made with chicken wire mesh and wooden posts (Figure 2) measuring 0.30 by 0.30 by 0.50 m (width, depth, and height). The alum cage was secured to the 2 inch GI inlet pipe of the 70 m^3 tanks.

A wire mesh cage is fixed onto the tank inlet to aid in alum dissolution.

Once the alum dose is determined by jar-test, the tank's alum requirement can then be calculated. Alum is added to the cage as the tank is being filled. In the case of the 70 m^3 tank, made up of three rings of corrugated sheets, the operators were instructed to divide the alum requirement into three portions and to add them to the cage as each third of the tank was being filled. The time needed to dissolve one third of the alum requirement was roughly the time necessary to fill up a third of the tank; indicating that the alum was dosed at an approximately constant rate. By means of the alum cage two problems are avoided: the need to dissolve the alum and the need for a stock solution doser.

Once water in the sedimentation tanks is left to settle, the flocs accumulate at the bottom of the tank where the tank outlet is usually located. If care is not taken, the settled floc will be drawn-off as the outlet valves are open. A simple arrangement using green flexible hose and a float (e.g. a jerrycan) can overcome this problem. The hose is attached to the bottom outlet and the other extremity is fixed on to the float. In such a manner the outlet of the tank is now effectively located at a few centimetres below the supernatant level ('supernatant' refers to the liquid between the sludge on the bottom and the scum on the surface) (Figure 3). This arrangement has been suggested in the Oxfam tank manuals[3] and its use in Gahri Doppata has proven to be effective. The only problem is that once the tank is emptied and filled again, an air lock can occur in the green flexible hose, which keeps the middle portions of the hose afloat and stops the flow of settled water. This prevents the arrangement from working when opening the outlet valve. Before doing so, the air in the hose must be expelled.

As the batch sedimentation tanks were filled, the presence of scum was noticed on the supernatant. This scum consisted mainly of foam and floating debris such as small pieces of plastic, wood, and leaves that made it through the pump footvalve. The alum cage actually served a dual role, as it also screened the floating debris. However, in order to eliminate the foam scum, an overflow scum collector had to be installed in the tank. This collector consisted of a PVC pipe cut in half along its length. One side of the pipe

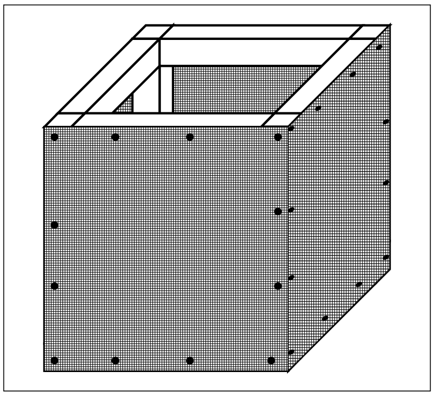


Figure 2. Alum cage, around which wire mesh is nailed on to wooden structure (0.30 by 0.30 by 0.50 m – not to scale)

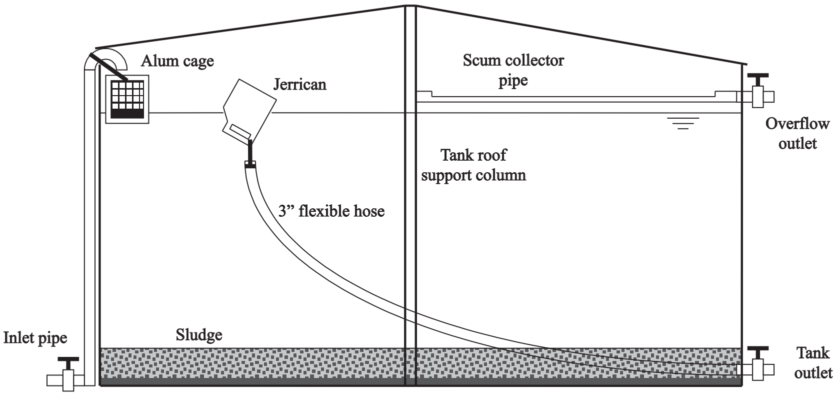


Figure 3. Floating outlet arrangement (alum cage and scum overflow also shown).

Scum on the surface of the water affects the turbidity of the treated water. The jerrycan supporting the floating outlet is also shown.

was attached to the roof support in the centre of the 70 m^3 tank (in smaller tanks the overflow pipe could be attached to the opposite wall of the tank). The other end of the pipe was fixed to the tank overflow outlet.

In order to eliminate the scum, the tanks were operated on overflow for about 3 to 5 minutes. This allowed for the collection and diversion of all the floating scum through the overflow outlet. The process was further facilitated by directing the incoming flow of water at a slight angle, allowing the water to fill the tank in a slow circular motion and easing the collection of the scum by the overflow collection pipe.

Summary

These emergency batch water treatment upgrades were tested and demonstrated in Pakistan. Under these conditions it was proved that significant improvements in process control and water quality could be obtained by means of simple solutions made from locally available resources.

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The scum collector pipe is fixed onto the tank roof support and overflow outlet.

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