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## Inclined plate settler for emergency water treatment: final design

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**WATER, SANITATION AND HYGIENE SERVICES BEYOND 2015:  
IMPROVING ACCESS AND SUSTAINABILITY**

## **Inclined plate settler for emergency water treatment: final design**

*G. Bédard, C. Bouchard & C.C. Dorea (Canada)*

**BRIEFING PAPER 2252**

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*Previously we reported on the proof-of-concept and initial optimisation work on an inclined plate settler (IPS) for water treatment in humanitarian situations. Whilst promising results (i.e. effluent turbidity < 5 NTU) were obtained, further work was warranted to better control and design the hydraulic flocculation (floc conditioning) stage of the treatment system. This paper reports on such work. A scaled-down version of the IPS was tested in parallel with several hydraulic flocculation configurations. The first deployment of the IPS is planned for 2015.*

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### **Introduction**

Diarrhoeal diseases can be one of the major contributors to the overall morbidity and mortality rates following a disaster (Connolly et al. 2004; Waring & Brown 2005). Therefore, with regard to water supply, adequate volumes (i.e. for personal hygiene) and “safe” water quality (i.e. for hydration purposes) are recommended (WHO 2005; The Sphere Project 2011). With this in mind and in order to overcome some limitations of current emergency “bulk” water treatment “kits” (Dorea et al. 2006), a new inclined plate settler (IPS) for humanitarian emergency water treatment system has been developed.



**Photograph 1. Original IPS prototype  
in Pune (India)**



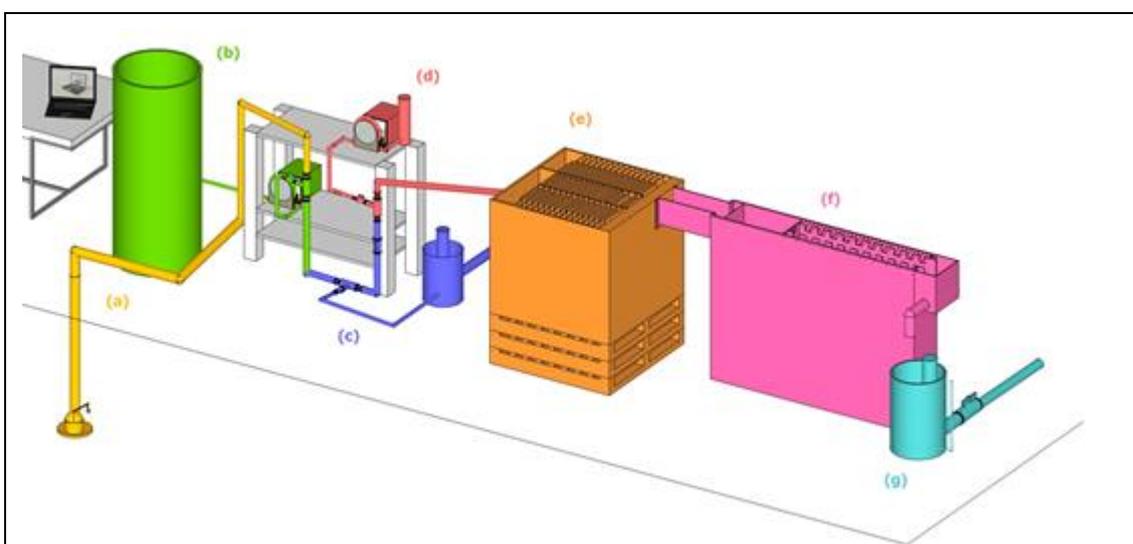
**Photograph 2. Modified IPS prototype with  
hydraulic flocculator extension and  
overflow launders**

Initially, the proof-of-concept of the IPS water treatment system (Photograph 1) was reported on (Dorea & Bourgault 2013). Subsequently, preliminary optimisation trials conducted in a test site in Pune (India) of the IPS with the addition of a flocculation stage (Photograph 2) were conducted (Dorea et al. 2014). Whilst promising results (i.e. effluent turbidity < 5 NTU) were obtained, further work was warranted to better control and design the hydraulic flocculation (i.e. floc conditioning) stage of the treatment system. To this

end, further trials in carefully-controlled conditions were conducted in Quebec City (Canada). This paper reports some results from such work.

## Materials and methods

A scaled-down (1/3) version of the IPS was commissioned in polypropylene with a throughput of 2 m<sup>3</sup>/h. The pilot IPS was installed at the downstream end of a test rig that allowed for different turbidities, coagulant doses, and hydraulic flocculation conditions to be tested (Figure 1). Kaolin was used as a surrogate for turbidity-causing particles and mixed into local tap water. Aluminium sulfate was dosed with a peristaltic pump connected to the “raw water” (i.e. tap water + kaolin) line. The hydraulic flocculator permitted different mixing intensities and baffle configurations, as further described elsewhere (Haarhoff & van der Walt 2001), to be tested, namely: over-and-under (O&U) and around-the-end (ATE). The scaled down IPS also permitted different plate configurations to be tested in order to improve the system’s turbidity reduction and hydraulic efficiency.



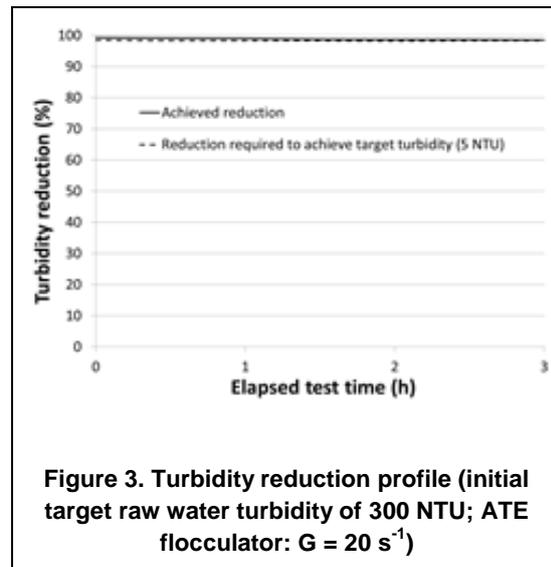
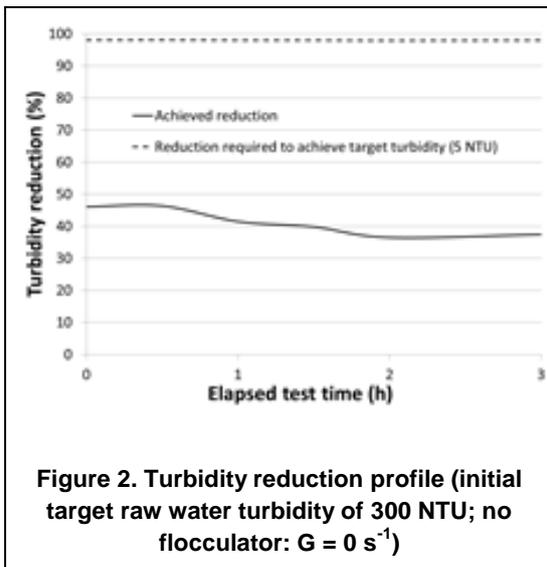
**Figure 1. Schematic of scaled down pilot testing rig for the IPS: (a) tap water reservoir feed; (b) kaolin slurry tank and feed; (c) “raw water” sampling and flow measurement; (d) coagulant doser; (e) hydraulic flocculator; (f) scaled-down inclined plate settler (IPS); (g) treated water sampling and collection.**

Source: Bédard (2015)

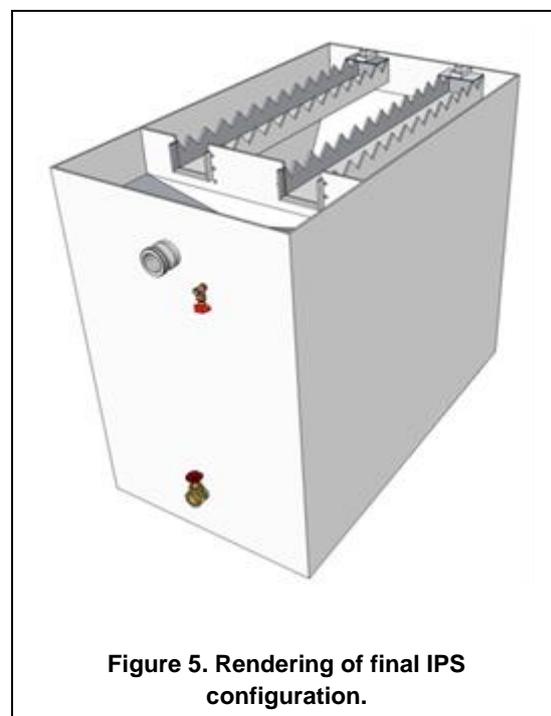
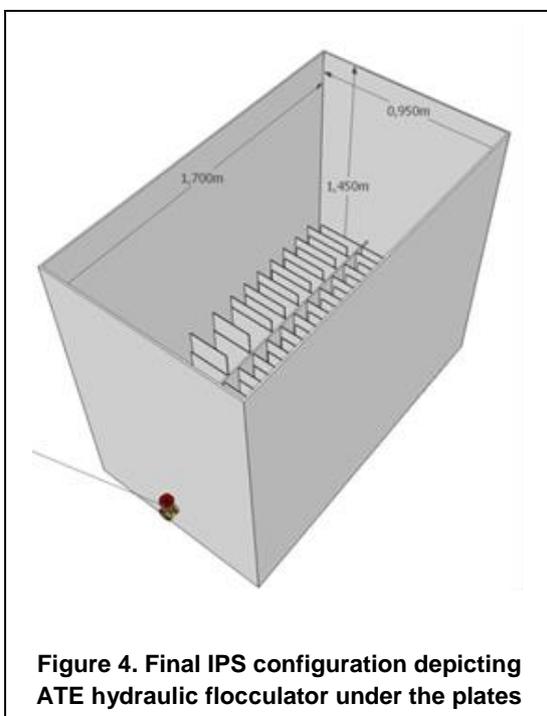
The overall objective of the testing was to obtain the flocculation configuration with minimal residence time (as this would imply a smaller final volume) that could achieve the treated water target (The Sphere Project 2011) of 5 nephelometric turbidity units (NTU). Initially, different hydraulic flocculator configurations were tested at a target raw water turbidity of 300 NTU. Configurations that attained the treated water target turbidity were kept and tested at a 5 minutes mixing time and then tested again at 50 NTU, as this would pose a theoretically more difficult condition for flocculation. Final verifications were then made at mixing times of less than 5 minutes and at raw water turbidities of 675 NTU to test the effect of high turbidities on the system performance.

## Results and discussion

The hydraulic flocculator allowed for the testing of different mixing intensities. A general trend was observed with decreasing average final turbidities with increasing average mixing intensities ( $G$ ) of up to 30 to 40 s<sup>-1</sup> (Figure 2 and 3). For the same mixing intensities, results tended to be better with the ATE type baffles in comparison to results obtained with O&U baffle configuration. Testing also revealed that within such a  $G$  range, the target treated turbidity could be achieved with 5 minutes of mixing, even when the influent turbidity was reduced to 50 NTU.



However, the system was unable to achieve sufficient turbidity reductions when the influent turbidity was of 675 NTU. In such conditions, only a final average turbidity of less than 10 NTU was achieved. The fact that in such conditions final turbidities were (slightly) in excess of the aesthetically-based 5 NTU target, the contexts in which the IPS would be used should be kept in mind. That is, attaining the 5 NTU value, or not, does not necessarily have any correlation with the visual acceptability of the finished water by the beneficiaries. It is unlikely that the final turbidity values of up to approximately 8 NTU (as frequently encountered under the high turbidity conditions tested) will pose a major problem with regards to its acceptability in comparison to acceptability at the target level of 5 NTU.



Based on the test results a final hydraulic flocculator arrangement using ATE type baffles was chosen with a mixing time of 5 minutes and an average  $G$  of  $30 \text{ s}^{-1}$ . Where  $G$  is a measure of the mixing intensity commonly applied to flocculators. This average  $G$  was achieved through a tapered (i.e. higher to lower

mixing intensities of 50 s<sup>-1</sup>, 18 s<sup>-1</sup>, and 9 s<sup>-1</sup>) hydraulic flocculator arrangement. Such a configuration also allowed the hydraulic flocculator to be installed under the IPS (Figure 4 and 5). The IPS is in its final stages of manufacture from fibre reinforced plastic (FRP) and should be ready for its first field deployment in 2015.

## Conclusions

Extensive testing of different hydraulic flocculator configurations allowed for an optimal arrangement to be selected for the IPS system. This allowed for target effluent turbidities to be achieved under normal (i.e. 300 NTU) and low (i.e. 50 NTU) design turbidity loadings. Although at high (i.e. 675 NTU) turbidity tests, final effluent was not less than 5 NTU, results were still considered satisfactory considering the context in which the IPS will be deployed.

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## References

- Connolly, M.A., Gayer, M., Ryan, M.J., Salama, P., Spiegel, P. and Heymann, D.L. (2004) Communicable diseases in complex emergencies: impact and challenges. *Lancet*, 364(9449): 1974-1983.
- Dorea, C.C., Bertrand, S. and Clarke, B.A. (2006) Particle separation options for emergency water treatment. *Water Science and Technology*, 53(7): 253-260.
- Dorea, C.C. and Bourgault, C. (2013) Inclined plate settling for emergency water treatment. In: *Proceedings of the 36th WEDC International Conference, Kenya*.
- Dorea, C.C., Williams, J.G., Boulay-Côté, F., Bédard, G. and Bouchard, C. (2014) Inclined plate settling for emergency water treatment: towards optimisation. In: *Proceedings of the 37th WEDC International Conference, Hanoi*.
- Haarhoff J. and van der Walt J.J. (2001) Towards optimal design parameters for around-the-end hydraulic flocculators. *Journal of Water Supply: Research and Technology—AQUA*, 50(3): 149-59.
- The Sphere Project (2011) *Humanitarian Charter and Minimum Standards in Disaster Response*, Practical Action, UK.
- Waring, S.C. and Brown, B.J. (2005) The threat of communicable diseases following natural disasters: a public health response. *Disaster Management & Response*, 3(2): 41-47.
- WHO (2005) *Communicable disease control in emergencies: A field manual*. WHO, Geneva, Switzerland.

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## Contact details

Caetano C. Dorea  
Département de génie civil et de génie des eaux  
Université Laval  
Québec, QC  
Canada G1V 0A6  
Tel: +1 418 656 7763  
Email: caetano.dorea@gci.ulaval.ca  
caetanodorea@hotmail.com  
www: <http://www.gci.ulaval.ca/caetanodorea>

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