Field testing of an onsite blackwater sanitation system for apartment building using electrochemical disinfection of biologically treated waste

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Abstract: The Closed Loop Advanced Sanitation System (CLASS) was designed to treat, disinfect, and recycle toilet blackwater from existing flush toilets in a multi-story apartment building. Two systems were tested at two unique sites in Coimbatore, India for a combined 7,500+ treatment hours resulting in more than 180,000 L of treated water. The CLASS prototypes used a combination of biological pre-treatment and electrochemical oxidation processes to produce treated water that nearly met the stringent requirements outlined in the standard ISO 30500. The treated water was reused for flushing by the residents of the apartment building for 89 days.

Keywords: reinvented toilet, electrochemical treatment, disinfection

Introduction, methods, results and discussion (500 words)

Minimizing the use of water or producing high quality water is of particular interest in water stressed areas of the world such as India [1] recently facing life-threatening water shortages in cities . To an increasing extent, wastewater is being seen as a resource that can provide freshwater rather than a waste to treat or discard. For instance, as illustrated by Sushmitha *et al.*, diverse greywater treatment and recycling projects are being implemented in increasing numbers across India [2]. Therefore, treatment and recycling of the remaining household wastewater (*i.e.* blackwater) presents an excellent opportunity to completely recycle wastewater generated at the household and alleviate the need of sewer connection . The challenges with onsite treatment of excreta are multiple: the treatment technology has to be reliable, easy to use, low-cost, and, more importantly, used by the intended people.

As Radjenovic and Sedlak identified [3], electrochemical wastewater treatment is a promising technology for onsite treatment of blackwater at the single-family (< 10 users/day) or small community levels (< 100 users/day). As of today, electrolysis of chloride into aqueous reactive chlorine species using semiconductor oxide anodes (*e.g.* $Ir_xTa_yO_2/TiO_2$) developed by some of these investigators have shown extremely high levels of disinfection and treatment of toilet wastewater in laboratory conditions and early field trials in India [4].

While the electrochemical system tested by Cid *et al.* was exclusively designed for usage in public areas (*i.e.* a park and a university campus) and tested with a relatively limited number of users, the system presented in this study was scaled up and re-engineered to treat and recycle the daily toilet wastewater of small apartment buildings with approximately 15 to 25 residents and 12 toilets. As of now, such apartment buildings, which often have onsite septic management system, hold promise as a market segment for this electrochemical treatment technology achieving

an optimal balance between capital expenditure and operational expenses of the treatment on one side, and water savings and environmental impact on the other side [5].

In this poster presentation we report the demonstration of this electrochemical disinfection technology at the scale of an apartment building, namely the CLASS system (Figure 1). Here we present the long-term performance study of the system in two residential buildings meeting the specific criteria for this application. The goal of the study was to answer the following questions and help the translation of this system into a commercial product: how does the electrochemical system perform at this scale and outside the lab in a relevant environment? Does the effluent meet relevant (*e.g.* ISO 30500) pathogen and nutrients threshold requirements? And, what are the additive and maintenance requirement of the electrochemical system?

Conclusions and implications (200 words)

This poster reports the demonstration of this electrochemical disinfection technology at the scale of an apartment building. Blackwater from two apartment buildings in India was treated onsite for 12+ months, producing over 180,000 L of clean water. Recycled water was used for toilet flushing for a sustained period of three months (89 days) during this field-testing period. The CLASS v2 prototypes consistently achieved high disinfection rates with E. coli counts below the assay detection limit. Efficient organic and nutrient removal were dependent upon the blackwater characteristics, which differed between the sites, as well as the performance of the biological pre-treatment and electrochemical systems. Upwards of 90% of the organic load was removed during the treatment process, and the effluent nearly met the stringent thresholds outlined in the ISO 30500 standard. The nutrient removal was variable for nitrogen (53-73%) and minimal for phosphorus.

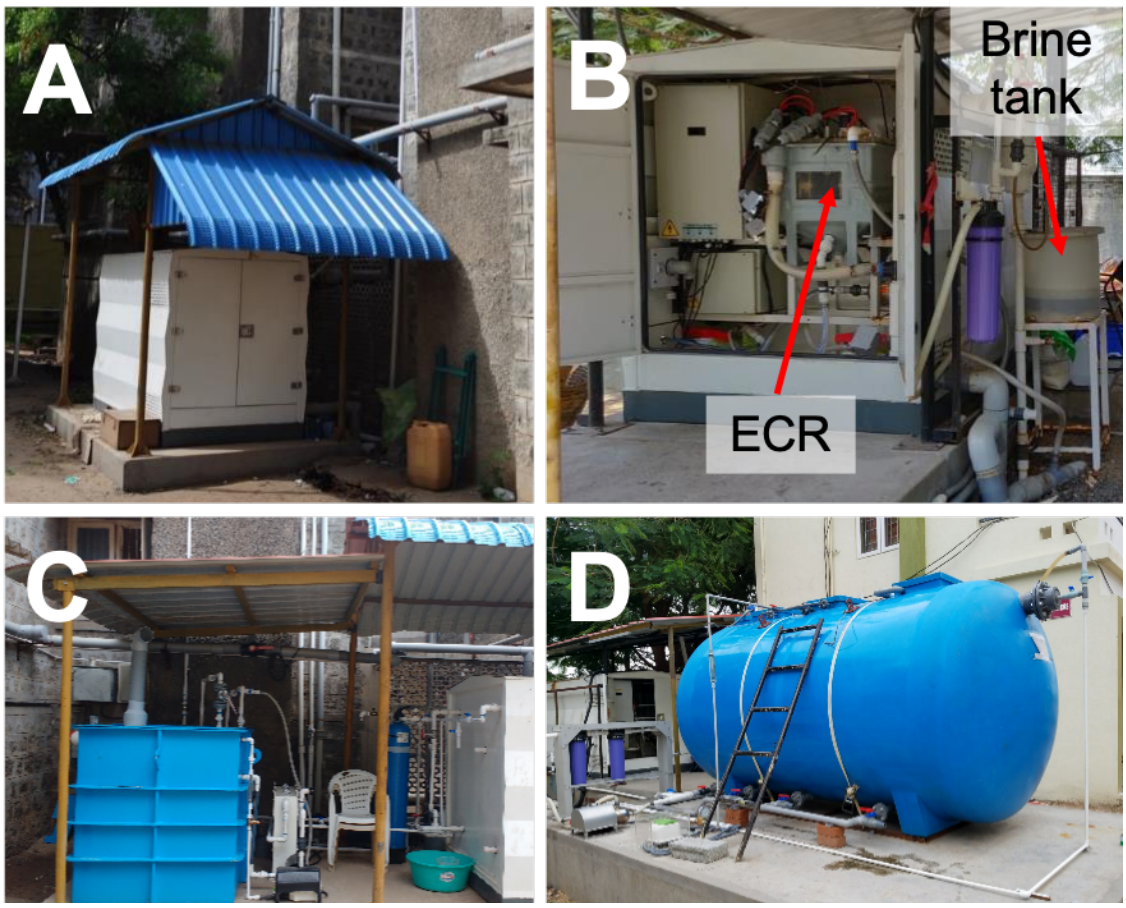

Figure 1: (A) Picture of the CLASS system (B) CLASS with open doors showing the ECR and with brine tank. (C) The SBR at site A. (D) The Ecosan digester at site B.

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