Research priorities and progress in faecal sludge dewatering

Author(s):
Ward, Barbara Jeanne; Sam, S.; Andriessen, N.; Morgenroth, Eberhard; Strande, L.

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Research Priorities and Progress in Faecal Sludge Dewatering

Difficulties in dewatering of faecal sludge are a crucial barrier to implementation of effective faecal sludge management. This article focuses on progress with locally available conditioners and the next steps toward implementing high-throughput, low-footprint dewatering technologies. B. J. Ward[1,2], S. Sam[1,2], N. Andriessen[1], E. Morgenroth[1,2], L. Strande[1]

Introduction

Faecal sludge, the waste collected in onsite sanitation systems, such as septic tanks and pit latrines, is typically more than 95 % water. Solid-liquid separation is necessary for faecal sludge treatment and safe disposal or resource recovery. The option to dewater faecal sludge at decentralised facilities would improve collection and transport logistics in traffic congested cities and high density slum areas that are not accessible to vacuum trucks. However, the existing dewatering methods for faecal sludge, for example, unplanted drying beds and settling-thickening tanks, require large land areas and are time-intensive. Residence times in settling-thickening tanks and on drying beds are on the order of weeks to months, limiting capacity at centralised faecal sludge treatment plants. The large footprint required for drying beds also makes them challenging to implement in dense urban environments where land is expensive and scarce. In order to expand sanitation coverage in urban areas, high-throughput and low-footprint technologies need to be adapted for faecal sludge.

Barbara Jeanne Ward

Photo 1: Settling tests on conditioned faecal sludge in Dakar, Senegal.

The case for conditioners

Conditioners are chemicals that facilitate rapid coagulation and flocculation of particles, which induce more complete settling and faster dewatering. Introducing conditioners has the potential to revolutionise the management of faecal sludge, if it can be determined how to use them reliably. Furthermore, this can lead to improvements in the effluent quality from settling-thickening tanks and reduce dewatering and drying time on drying beds, which can increase the treatment capacity of existing facilities. Conditioners are necessary for many low-footprint dewatering technologies. For example, mechanical dewatering technologies, such as belt and filter presses, and passive dewatering technologies, e.g. geotextile bags that rely on filtration to separate solids from liquids, only work with the addition of conditioners. Without conditioning, small colloidal particles within the sludge quickly clog the filter and dewatering cannot proceed.

Many previous trials with geotextiles and mechanical dewatering technologies have been unsuccessful due to difficulties in reliably conditioning faecal sludge. In order to form strong flocs and bind colloidal particles, the appropriate conditioner must be determined and added at a correct dose. Conditioner selection and dose depend on physical and chemical properties of the sludge (e.g., TSS, pH, salinity and surface charge), which can vary by orders of magnitude with each batch of influent sludge.

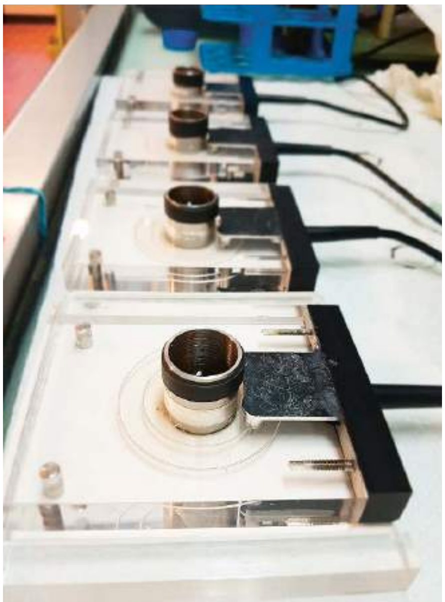
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Photo 2: Capillary suction time tests to measure filtration speed of faecal sludge.

Lab-scale and pilot conditioner research

To improve the understanding of the performance and optimal dosage of a range of conditioners for faecal sludge, bench-scale trials were performed in Dakar, Senegal [1]. Locally available natural conditioners chitosan and *Moringa oleifera* showed settling and dewatering performance similar to standard polymer conditioners used for wastewater treatment. However, *M. oleifera* required very high doses to reach optimal performance, which contributed to increased COD and nutrient loading in the effluent. In contrast, chitosan required much lower optimal doses to achieve the same performance as *M. oleifera* (Table 1).
Due to their relative success in laboratory trials, the performance of chitosan and *M. oleifera* were analysed at pilot scale with unplanted drying beds in Dar es Salaam, Tanzania [2]. Despite differences in faecal sludge between the cities, optimal doses of the conditioners were comparable (Table 1). This is significant, as it is the first step in comparing the performance of single conditioners across a variety of faecal sludge samples. Conditioning with chitosan reduced dewatering and drying times on drying beds by 53 % and 13–18 %, respectively, compared to unconditioned sludge. Adding chitosan did not measurably influence the effluent quality, measured by TSS removal in the effluent from the drying beds; 99 % removal was observed in trials with and without conditioning.
Our research has identified chitosan as a high performing conditioner for faecal sludge on drying beds, but optimising conditioning with chitosan requires better understanding of appropriate dosing. Currently, the optimal doses of conditioners have to be determined individually for each batch of sludge with trial and error. However, this method is too time and labour intensive for practical application. The key question to answer is: how can we translate our research results with conditioners, which have worked well for different faecal sludges, to progress to rapid online process control on a larger scale?

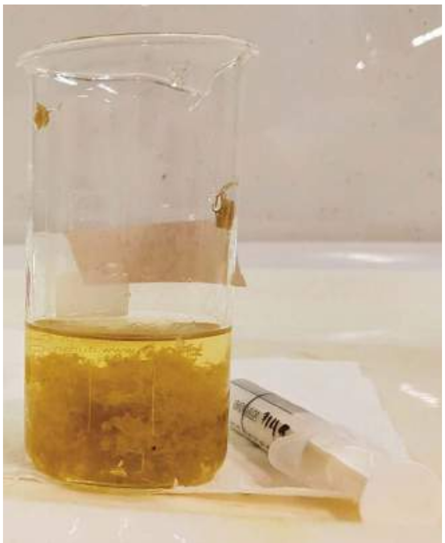
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Photo 4: Faecal sludge after conditioning with polymer flocculant. Distinct flocs are visible and the supernatant turbidity is reduced.

Conclusion

In 2018, B.J. Ward and Stanley Sam began PhD research projects to further investigate the improvement of faecal sludge dewatering. Their research will focus on identifying the underlying mechanisms governing settling and dewatering behaviour in faecal sludge. The influence of faecal sludge microorganisms and their degradation and production of biopolymers, along with the effects of particle properties, surface charge, and solution properties, will be examined in order to develop a unified theory of faecal sludge dewatering behaviour. Once the controlling mechanisms have been identified, rapid or online measurements for practical use can be determined that link back to fundamental behaviour. The hopeful outcome of this research will be a model based on rapid influent sludge characterisation to predict conditioner dosage in real-time. Collaborations with partners throughout Asia and Africa to validate the model and improve trials with drying beds, settling-thickening tanks, and low-footprint dewatering technologies will continue.


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Photo 3: Preparing for microbial community analysis of faecal sludge. Future work will investigate the link between dewatering performance and bacterial populations.

[1] Gold, M., Dayer, P., Faye, M., Clair, G., Seck, A., Niange, S., Morgenroth, E., Strande, L. (2016): Locally produced natural conditioners for dewatering of faecal sludge. Environmental Technology *37 (21),* 2802–2814.

[2] Moto, N., Esanju, M., Andriessen, N., Kimwaga, R., Strande, L. (2018): Use of chitosan and Moringa oleifera as conditioners for improved dewatering of faecal sludge. 41st WEDC International Conference, Nakuru, Kenya.

	Optimal conditioner dose (kg/tonne TS)	
	Chitosan	***Moringa oleifera***
Dakar	1.5–3.8	400–500
Dar es Salaam	2.5–3.0	250–750

Table 1: Optimal conditioner dose for faecal sludge samples from Dakar and Dar es Salaam for locally available conditioners chitosan and *M. oleifera.*

[1] Eawag/Sandec, Switzerland
[2] ETH, Switzerland
Contact: barbarajeanne.ward@eawag.ch