Measuring pit latrine sludge shear strength and total solids from rapid in-situ penetrometer tests

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Summary

Emerging guidelines for assessing faecal sludge quantities and qualities at city scale are applied in Kampala, Uganda alongside a rapid in-situ penetrometer test for sludge shear strength as a proxy for total solids content. Data are presented from 70 pits, tested both in-situ and for total solids content in the lab to establish a correlation. The results obtained so far have been correlated to accessible demographic, environmental, and technical data as predictors of sludge qualities. This new approach will be evaluated against current practice of basing investment decisions upon average values for faecal sludge taken from an extremely limited number of samples.

Problem

It is widely accepted that effective faecal sludge management requires location-specific data on the quantities and qualities (or characteristics) of the sludge to design an appropriate system. This is because key qualities range by at least two orders of magnitude globally. For example, total solids (TS) required for sizing drying beds can vary from 0.1% to over 10% and shear strength a principal measure of ‘pumpability‘ can vary from 50Pa to over 5000Pa. However, relatively few studies have been undertaken at city-scale, and those that have do not present the distribution of those faecal sludge qualities, but rather average values with standard deviations comparable to the median.

Solution

Water for People Uganda alongside key stakeholders Kampala Capital City Authority (KCCA) and Mott McDonald-UK has supported innovation and application of a ball penetrometer devise in profiling in-situ pit latrine shear strength. This ball penetrometer applies emerging guidelines for assessing quantities and qualities of faecal sludge for planning and management, building on previous work by Schöbitz et al in Kampala, Uganda that collected demographic, environmental, and technical data at city-scale and further developed by Strande et al to develop predictors for faecal sludge quantities and qualities. However, it goes one step further, by attempting to replace the sampling process with a simple and rapid in-situ test for sludge strength. The benefit of eliminating sampling is that it is time consuming and logistically challenging; samples need to be extracted and safely transported to a competent laboratory, which in itself may change some of the sludge qualities. It therefore becomes a relatively expensive data collection process to the extent that current diagnostic guidelines suggest taking just five sludge samples for characterization across a whole city, while cluster surveys would be used to deliver a questionnaire to perhaps five hundred households.

Method

Sludge strength data has been collected for 70 pits (to date, but continuing) in selected parishes in Kampala, using an updated version of the Radford & Sugden digital penetrometer that provides a continuous profile of strength with depth. Tests are conducted in-situ at the pit and with a skilled operator take approximately half an hour (photo 1). Grab samples of faecal sludge were then taken from specific depths within each pit to target layers of different strength (identified using the penetrometer), and tested for total solids content. A household survey was also undertaken with each test to collect corresponding demographic, environmental and technical data.

Photograph 1: Pit tests in one of the parishes

Results

The preliminary results indicated a correlation between shear strength and total solids content (Figure 1), which is currently relatively weak with R^2 of approximately 40%. However, as further data is collected it could provide a useful predictor of total solids content from a relatively simple and rapid test. Further work is ongoing to test correlations between the shear strength data and the corresponding demographic, environmental, and technical data to enable improved city-scale predictions to be made from this sludge strength sample data.

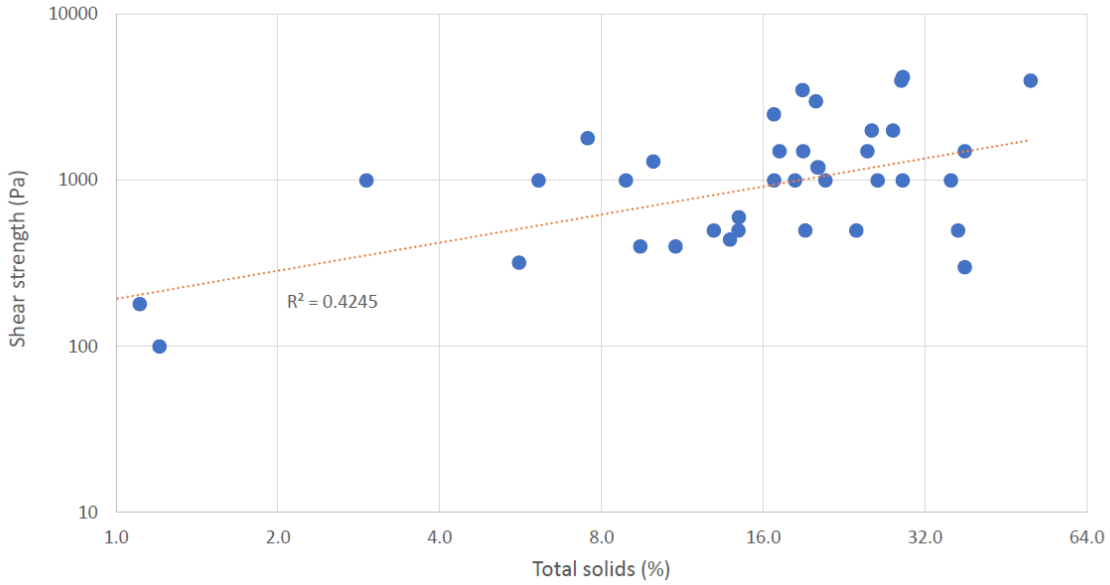

Figure 2: sample results for shear strength vs total solids content

Implications

The results suggest that a relatively simple and rapid test for sludge shear strength could be used to estimate total solids content, with work ongoing to build correlations that enable that data to be extrapolated to city-scale and improve current predictions. It becomes feasible to scale-up data collection one hundred-fold and test sludge shear strength as part of the household survey undertaken during diagnostic studies. That data, providing a direct measurement of sludge 'pumpability' and an estimate using the correlation presented here of total solids content (a key characteristic for sizing treatment plants), could then be extrapolated to city-scale and enable better investment decisions for effective faecal sludge management systems.

References

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