Optimising Unplanted Faecal Sludge Drying Beds in Devanahalli, India

Worldwide, operators of unplanted drying beds constantly have to deal with the challenges of varying sludge volumes and characteristics. This article presents three modifications that operators in Devanahalli tested to improve unplanted drying bed performance. Anantha Moorthy[2], Nienke Andriessen[1], Rohini Pradeep[2], Linda Strande[1]

Introduction

Unplanted drying beds are commonly used worldwide for faecal sludge dewatering. Drying beds are passive gravity filters that are an attractive treatment option due to their ease of operation. However, several operational difficulties exist that affect the consistency of treatment performance, including sludge variability, environmental factors (e.g. temperature, humidity, wind and precipitation), and sand removal with dewatered sludge. This makes the reality of operation frequently different from design parameters, and can result in poor treatment performance [1]. To improve the reliability of treatment and operating performance, interventions are needed to adapt the actual operation of faecal sludge treatment plants (FSTPs) for this variability. Three strategies were tested at the Devanahalli FSTP in India to reduce maintenance costs and enhance the quality of resource recovery:

1) using linear models to evaluate optimal hydraulic loading rates;
2) installing greenhouses to increase drying speed;
3) utilising porous "Mangalore" tiles to avoid sand loss.

To learn more, please refer to two recent CDD publications [2, 3].

Methods

The Devanahalli FSTP was constructed in 2015 and has a total capacity of 6 m^3/day [2]. It treats faecal sludge from pit latrines and septic tanks, and is currently operating at 5 m^3/day. The process flow consists of a screening chamber, a settling tank, an anaerobic digester, an anaerobic stabilisation tank with three chambers for homogenisation and then settling. This is followed by 10 unplanted drying beds, with the liquid stream going to a combined anaerobic baffled reactor-anaerobic filter and a planted gravel filter [2, 3].

A total of 29 drying cycles were carried out to evaluate the effect of the three strategies on drying bed performance and each drying cycle entailed loading, drying, and removing the sludge. In this article, one drying cycle is referred to as drying time. Total solids (TS) and volatile solids (VS) were measured on the dried sludge. Air temperature and humidity were monitored with sensors inside the greenhouse, and were used to calculate an evaporation factor, defined as *(100 – Air humidity [%]) × Air temperature [°C]*. To evaluate loss of sand from the filter media, the height of the sand was determined after the sludge was removed by measuring the height of the remaining sand layer in the corners and the centre of the bed. A linear model was fitted to both total drying time (days/drying cycle) and normalised drying time, which was defined as drying time per cubic meter of sludge. Model inputs were selected based on theoretical reasoning and evaluation of the possible input parameters.

Results

Linear models

The collected data was analysed to find out if it could be explained by a model, which could be used in the future to optimise loading rates for drying efficiency. The linear model for total drying time was *Drying time [days/drying cycle] = 36.6 + 1.4 × Hydraulic loading rate [cm] +* 2.0×10^{-5} *× TS [g/L] – 26.7 × VS/TS ratio – 0.023 × Evaporation factor*. In this model, the hydraulic loading rate was significant ($p=<0.001$) and best explained variability in the drying time. For instance, increasing the hydraulic loading rate (in cm) one unit, increased the drying time by 1.4 days. That means, when varying the hydraulic loading rate by 5 cm, the model predicts a seven day difference in total drying time.

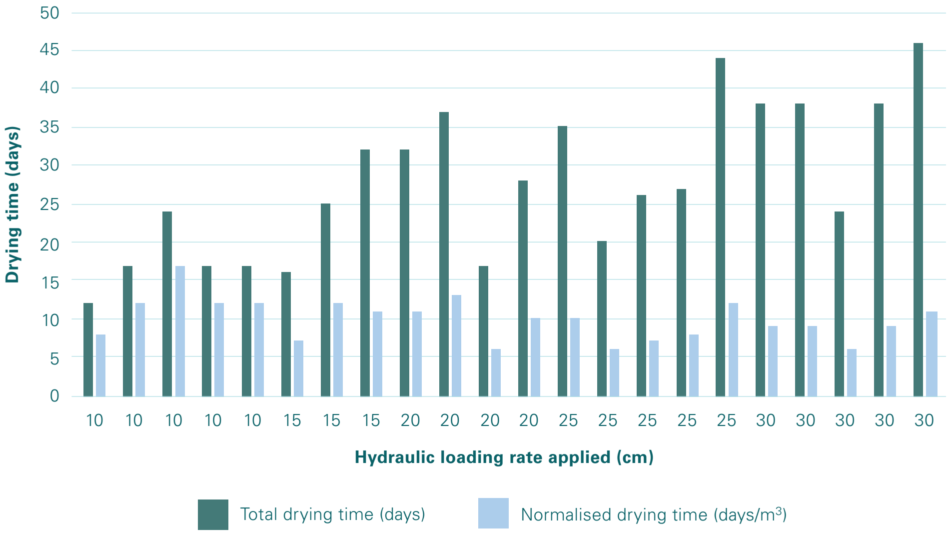

Figure 1: Time for drying of sludge on unplanted drying beds with applied hydraulic loading rates of 10, 15, 20, 25, and 30 cm. Each point represents one drying cycle. Shown are the total drying time/drying cycle in days (black circles) and the normalised drying time in days/m^3 (blue triangles).

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Photo: Mangalore tiles in a drying bed (top), sand added to the bed (middle), and greenhouses installed over drying beds (below).

The linear model equation for normalised drying time was *Normalised drying time [days/m^2] = 24.9 – 0.0088 × Hydraulic loading rate [cm] + 2.5×10^{-5} × TS [g/L] – 12 × VS/TS ratio – 0.0082 × Evaporation factor*. Here, hydraulic loading rate was not significant in the model (p=0.92), which means that for normalised drying time, the applied hydraulic loading rate was not as relevant. While drying time shows an increasing trend, normalised drying time shows a slightly decreasing trend with the increase in hydraulic loading rate, as seen in Figure 1. This suggests that if the operators wanted to dewater as much sludge as possible at Devanahalli, a hydraulic loading of 30 cm should be applied. These examples provide a first exploration of using linear models in the context of drying time, and can assist in predicting drying time for the case of Devanahalli.

Greenhouses

Installing greenhouses increased the average air temperature from 25 °C to 53 °C. Air humidity decreased from 56 % to 12 % on average, with the help of an integrated ventilation system. As shown in Figure 2, this resulted in a marked improvement in drying time, and more trials will be done. These initial results suggest that by installing greenhouses, operators could increase the number of drying cycles/year, and thereby treat a larger sludge volume on the same surface area. However, operators will need to do a cost-benefit analysis to justify the cost of building greenhouses (see Photo).

Mangalore tiles

Sand loss prior to tiles being installed was on average 6 cm per bed for 14 drying cycles that took place over two years of operation. After installation, sand loss was negligible during seven drying cycles/bed over six months and initial results are promising. Limiting the sand content for better product quality is beneficial when the sludge is used for resource recovery as a solid fuel or compost. Using locally available porous tiles can help reduce costs, but the decision to use tiles will also require a cost-benefit analysis, comparing different options and lengths of operation.

Conclusion

The research findings were the following:

- Empirical models developed with operating parameters specific to individual FSTPs are relatively easy to produce and could provide a way to optimise loading rates.
- Greenhouses are effective in reducing drying time.
- Mangalore and other types of locally available tiles can be effective in reducing sand loss.
- By rapidly testing and trying out adaptable solutions, treatment performance can be optimised during actual operation.

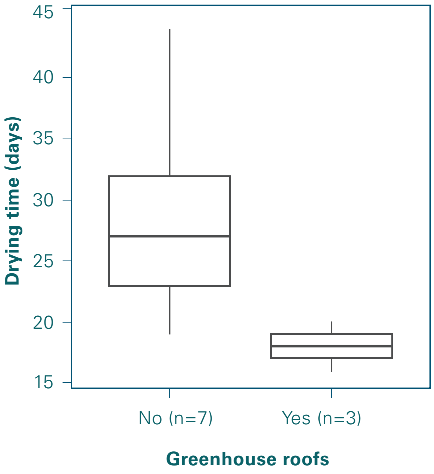

Figure 2: Total drying time per drying cycle with and without greenhouse roofs (applied hydraulic loading rate 25 cm, total 10 cycles).

References

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