

Mechanical Dewatering for Fecal Sludge Treatment Applications Process & Technology Review

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Evolving trends in fecal sludge treatment

Waste stabilization ponds have been the leading fecal sludge (FS) treatment solution for decades. And for good reasons. When properly designed and sized, WSPs deliver high quality effluent at marginal running costs. Their minimal maintenance requirements make them relatively hard to break – the textbook example of “appropriate technology”.

The simplicity and elegance of natural treatments systems will always have a special place in the hearts of many sanitation engineers but their large footprint has made them increasingly difficult to site in rapidly growing cities. Furthermore, trends toward resource recovery are changing the calculus for “appropriate technology”; these days, maximizing net financial recovery may trump achieving the bare minimum operating cost.

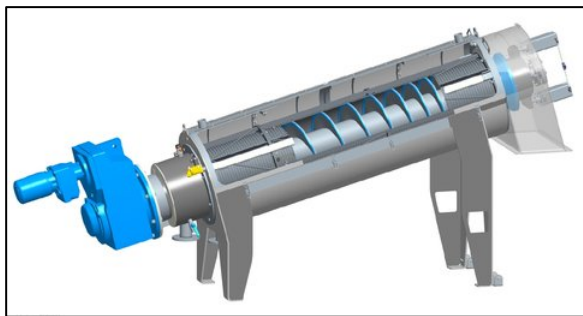
The bottom line is that smaller footprint mechanical systems are playing an increasingly important role in FS treatment process trains. At our former company, Pivot, mechanical dewatering was at the center of our fecal sludge-to-fuel conversion process. Sufficiently dewatered solids are also the necessary feedstock for the leading Omni-Processor technology, as is true for any process that is utilizing sludge solids for solid fuel or agricultural endpoints.

This article is a synthesis of our years of experience operating mechanical dewatering equipment and vetting tens of technologies. The article includes comparative costs as well as design and operational considerations. Our views on the benefits and potential challenges associated with deploying mechanical dewatering technologies are also presented.

Mechanical dewatering technology options

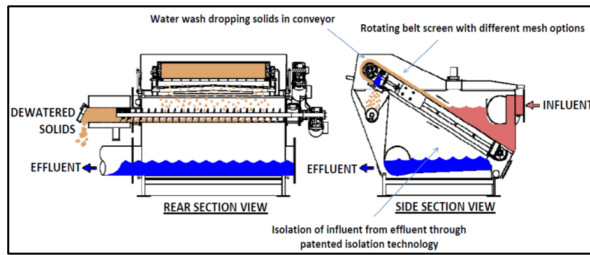
Mechanical dewatering refers to the physical separation of the liquid and solid fractions of a wastewater or fecal sludge stream. Within the category of mechanical dewatering equipment, there are six widely known technology options – rotary screw press, microscreen, belt press, centrifuge, rotary fan press, and filter press – each of which are briefly described and pictured below.

Rotary screw press. Sludge is conveyed through a screw enclosed by an outer screen. Dewatering is accomplished as gravity drainage allows the filtrate to fall out of solution and the solids are compressed and dewatered as the screw diameter decreases towards the outlet of the pipe.



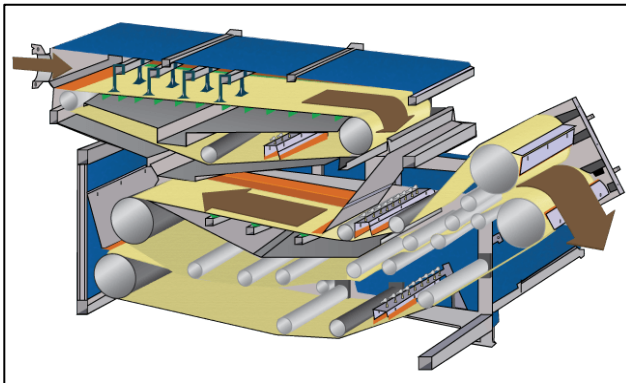
*Schematic of Huber's rotary screw press.
Source: Huber Technology Inc., 2018.*

Microscreen. Sludge is transported on a rotating belt, which uses gravity and a porous screen for solids separation. Liquid penetrates the screen and solids remain on top.



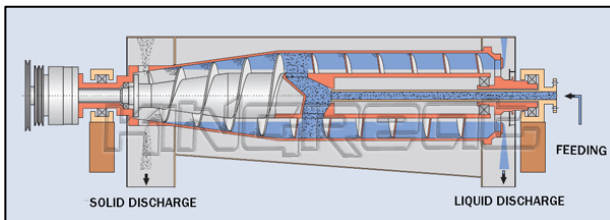
Schematic of M2R microscreen. Source: M2 Renewables, 2015.

Belt press. Sludge is distributed on a gravity belt section where free water drains through the porous fabric belt. The solids, which remain on top, are then pressed between two belts as the belts move in a serpentine pattern over a series of rollers. Each pass over a roller provides additional pressing force and removes additional water.



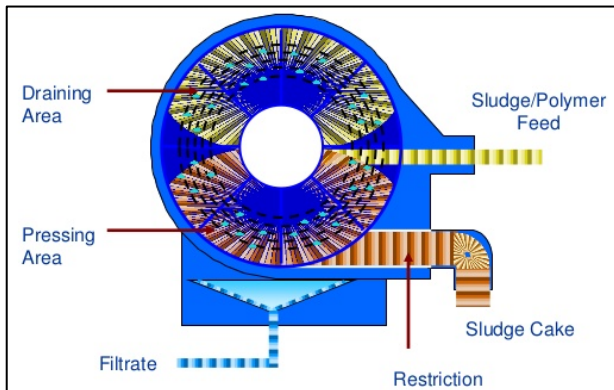
Schematic of FRC belt press. Source: FRC Systems Inc., 2018.

Centrifuge. Sludge is placed in a cylindrical bowl and rotated at high speed. The applied centrifugal force causes the suspended solids to migrate through the liquid, away from the axis of rotation due to the difference in densities between the solids and liquids.



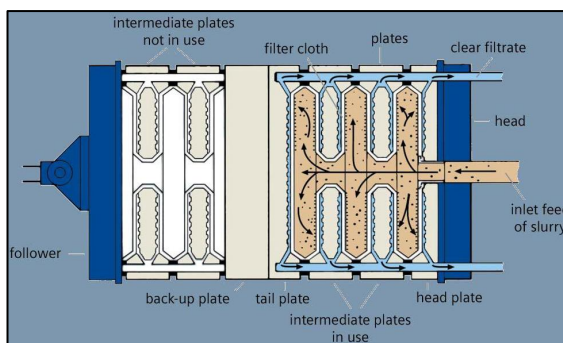
Schematic Kingreat decanter centrifuge.
Source: Kingreat Machinery Inc., 2018.

Rotary fan press. Sludge is fed into a rectangular channel and rotated between two parallel plated screens. The liquid passes through the screens while the sludge advances through the channel. Sludge cake is ultimately extruded from the outlet.



Schematic rotary fan press. Source: CDM Smith 2012.

Filter press. Sludge is fed into vertical chambers of filters. Moving plates exert pressure on the sludge, causing filtrate to pass through the cloth filters while the solids collect on the surface.



Schematic filter press. Source: Siemens Industry, Inc., 2018.

Comparative performance of mechanical dewatering technologies

The suitability of a mechanical dewatering technology depends on a number of factors including the feedstock type, the purpose of dewatering (e.g., to minimize strength of effluent, maximize solids recovery), and the fate of the solids. In the last three years, we reviewed technologies supplied by over 25 vendors through a process of contacting sales representatives and tech support, interviewing current users, and for a sub-set of equipment, conducting bench tests with fecal sludge samples and operating full-scale units. The table below provides a qualitative summary of some of the key selection and performance parameters for dewatering equipment used for FS applications.

Comparative cost and performance of six leading mechanical dewatering technologies.

	Capital cost	Power demand	Labor demand	Polymer demand	Solids capture	Cake solids
Rotary screw press	Low-Moderate	Low	Low	Moderate	Moderate	Moderate-high
Microscreen	High	Moderate	High	Moderate	Moderate	Low
Belt press	High	Low-moderate	Moderate	Moderate	High	Moderate
Centrifuge	Low-moderate	High	Low	High	Moderate	High
Rotary fan press	Moderate-High	Low-moderate	Low	Low	High	High
Filter press	Low	Low-moderate	Moderate	High	Moderate	Moderate

From the table above, the screw press and rotary fan press emerge as potentially most suitable technologies for fecal sludge applications. The rotary screw press is the most ubiquitous technology on the market and has solidly average to strong performance across key decision metrics. The rotary fan press is an emerging technology, which outperforms others in terms of solids capture and generating a low-moisture cake; however, it has a high capital cost.

In the context of fecal sludge treatment in emerging markets, centrifuges are almost certainly off the table. While good at their job, the power demand is an order of magnitude higher than any other technology and they have significantly higher polymer requirements than most other options. Microscreens also prove to be poorly suited for fecal sludge applications. Belt presses are known to have high labor requirements and are susceptible to frequent maintenance challenges, which detract from their suitability.

Design considerations

Based on our comprehensive research and years of operating dewatering equipment, the following considerations derive from our most important lessons learned with respect to technology selection and system design and operation.

Technology selection and specifications

- Throughput is solids-limited not volume-limited. When sizing (and pricing) dewatering equipment, the key consideration is the solids flow per hour (i.e., kg dry solids/hr) not the total volume per hour. Solids are the rate-limiting factor in terms of the system's performance and capacity. For example, a system receiving 100 m³/d at 4% solids needs to be four times the capacity of a system receiving 100 m³/d at 1% solids.
- Solids endpoint should inform technology choice. There are a lot of trade-offs between cost and performance of dewatering systems so "good" performance is really subject to the goals of dewatering. Solids capture, for example, ranges from 90-99% and cake dryness can range from 15% to >35% total solids. If maximum solids recovery and/or solids dryness aren't critical, don't pay for it in the capital or running costs.

System design and operation

- Sludge thickening. Most dewatering technologies are at peak performance with feedstocks in the 3-5% range. Therefore, sludge thickening is an important step for more dilute fecal sludge. Polymer dosing rates also decrease with increased solids concentration (up to a point), which makes another strong financial argument for pre-thickening. It's worth noting that while thickening is a simple process, careful and informed engineering design of the settling tank is critical. This is important to minimize footprint, optimize settling efficiency, and limit suspended solids in the supernatant, which can severely impact effluent treatment.
- Polymer. Every mechanical dewatering technology that we've seen on the market requires polymer to properly function – don't be tricked into thinking otherwise! Flocculating the sludge is critical to facilitating the physical process of liquid-solid separation.
- Automated polymer mixing and dosing. Manually mixing and dosing polymer is a time and labor-intensive process. It is also difficult to achieve a fully mixed solution, which leads to higher polymer consumption. In-line polymer dosing units are a compulsory component of many technologies but if not included, are worth the added investment.

Benefits and potential challenges with mechanical dewatering

There are several benefits associated with incorporating mechanical dewatering into fecal sludge treatment but compared to natural systems they introduce vulnerabilities in terms of cost, maintenance, and consumables. We conclude this review with a summary of some of the key benefits and challenges to expanding the use of mechanical dewatering in fecal sludge treatment applications.

Benefits

- Maximize resource recovery potential. Both the liquid and solid cake streams from dewatering systems are well suited for onward treatment and reuse. For solid energy endpoints, extraction at the headworks of a plant facilitates maximum energy recovery. The liquid is also suited for minimum further treatment prior to reuse in industrial or agricultural applications.
- Minimize footprint. In a matter of seconds and on a footprint of about 10 m², mechanical dewatering systems remove upwards of 95% of total solids from a waste stream. This could, for example, eliminate the need for a 350 m² anaerobic pond in a WSP system – a big deal in growing cities.
- Minimize downstream treatment requirements and costs. Solids removal at the beginning of the fecal sludge treatment process serves to homogenize and reduce the strength of the liquid effluent, thus reducing onward treatment requirements. In a comprehensive lifecycle assessment, the added cost of mechanical dewatering is often offset by the capital and operating savings for secondary treatment. Dewatering effluent can go directly into an anaerobic baffled reactor, facultative pond, or renders FS suitable for co-treatment in an existing sewage treatment plant.

Challenges

- Polymer supply chain. Polymer is critical to the proper operation of mechanical dewatering systems and will need to be imported into most developing countries. There are no manufacturers in sub-Saharan Africa and while there are several in India and China, we cannot speak to their quality or reliability. Shipping costs (into East Africa, anyway) can nearly double the factory gate price of polymer.
- Breakable parts. Mechanical dewatering equipment requires routine maintenance and will almost certainly require replacement parts in its operating lifetime. If spares aren't readily available – or affordable – a broken dewatering system will compromise the performance of all downstream components of a plant.
- Power supply requirement. The power demand of most mechanical dewatering systems is fairly modest. Nonetheless, the equipment will not function in the event of a power cut unless connected to a back-up generator. Solar with battery storage could be a very reasonable option for powering dewatering equipment.