

Sludge Thickening, Dewatering, and Drying Technologies

A summary of known solutions

Sludge dewatering by GeoTube®. Image Source: Admir Technologies

JANUARY 2018

The Sanitation Technology Platform

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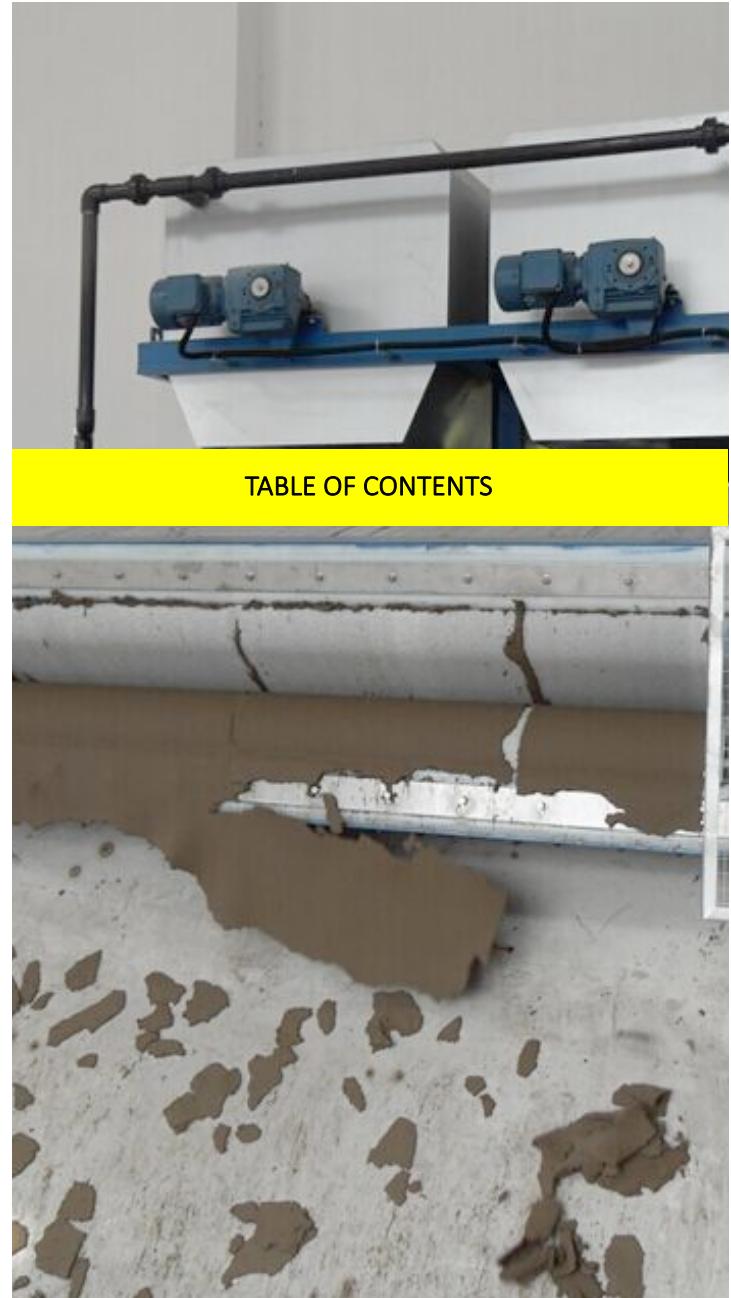


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Overview

Sludge pre-processing is an essential part of fecal sludge management (FSM). Sludge treatment has historically focused on decreasing sludge volume for the purpose of reducing transport and disposal costs; however, new emphasis on pathogen elimination and resource creation has driven the development of new technologies.

The Bill & Melinda Gates Foundation (BMGF) is funding new product development in the sanitation sector. Most of the Reinvented Toilet (RT) and Omni Processor (OP) technologies require fecal sludge (FS) dewatering, with varying requirements around outlet characteristics. To help technology partners (TPs) and commercial partners (CPs) identify pre-processing systems that meet their needs, STeP has compiled data from numerous independent reports into this working document.

Technologies Covered

Three types of pre-processing technologies are included in this analysis: thickening technologies, dewatering technologies, and thermal drying technologies. Sludge thickening is typically the first step aimed at removing free water and increasing the concentration of sludge from very dilute to a thicker, more concentrated solution of 2%–15% total solids (TS). The most common types of sludge thickening are gravity thickening, rotary drum thickening, and dissolved air flotation thickening. Sludge dewatering removes water from the interstices between sludge particles and typically achieves 20%–25% TS, with a few exceptions. Common dewatering methods include presses, centrifuges, and drying beds. Thermal drying technologies force off bound water and can achieve up to 92% TS. Only two thermal drying technologies are featured in this report, which does not reflect the breadth of systems available in the marketplace.

Data Sources

Readers should use caution when interpreting capital and lifecycle cost data, as certain systems were evaluated at a specific scale (see footnotes throughout) and with India-specific input assumptions for labor, electricity, etc.; therefore, findings may not be reflective of all situations.

The majority of the data in this analysis is derived from four key sources:¹

- STeP: secondary research and primary interviews with nine equipment manufacturers
- Isle Consulting Report for BMGF: primary research with three equipment manufacturers and secondary data on a fourth
- Intellectual Ventures RFI for new dewatering technologies: secondary research of established and emerging technologies
- Partner-published reports, where noted

The following manufacturers provided inputs on this analysis:



Communicating New Data to STeP

This is intended to be a working document that evolves with inputs from the broader sanitation community. If you would like to contribute to this analysis, please email Andrea Stowell at astowell@rti.org.

¹Where available, primary data was used in place of secondary data.

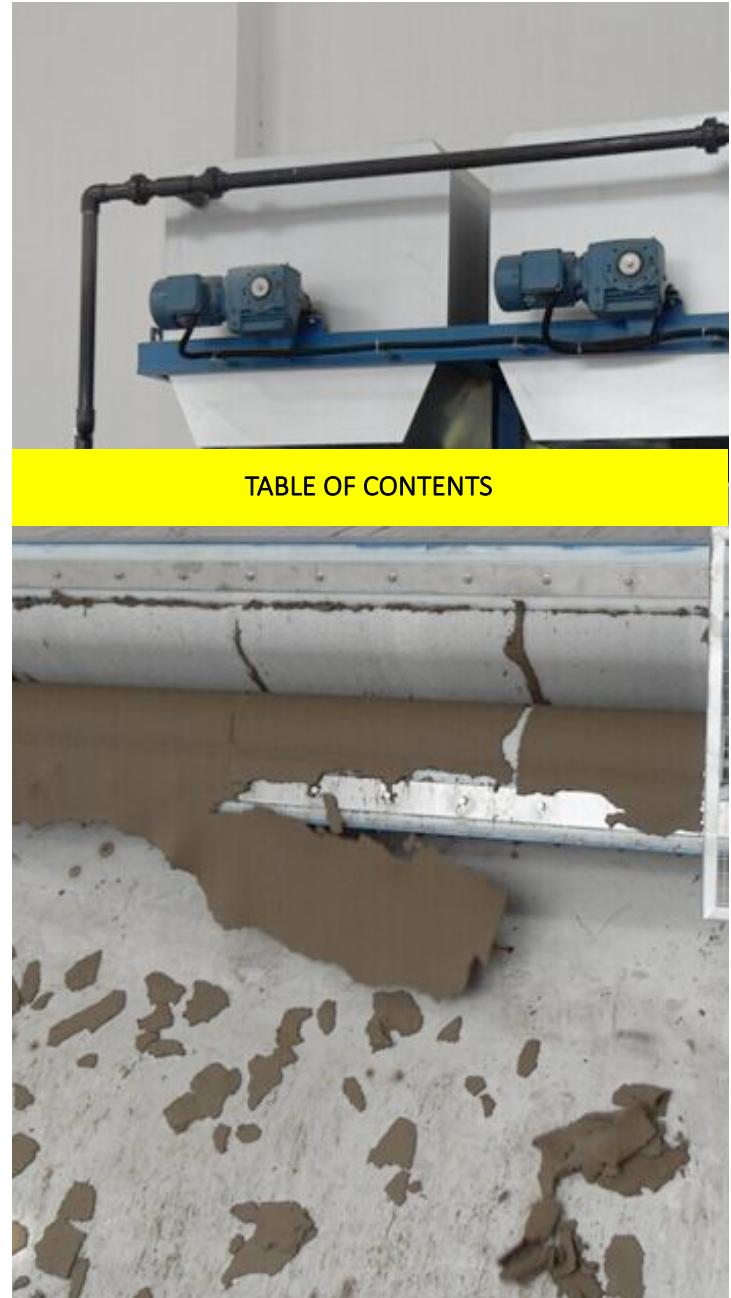


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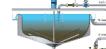
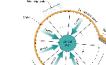
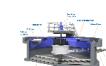
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Thickening Technologies

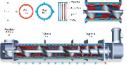
Dewatering Technologies

Thermal Sludge Drying

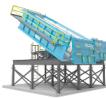
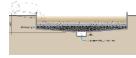
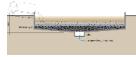
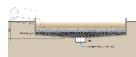
Sludge Thickening: Overview of Common Technologies

Thickening Technology	Established or Emerging	Technology Vendors	Outlet Cake Solid (%)	Footprint	Experience with FS	Suitable for large volume	Capital Cost ¹	20-Year Lifecycle Cost ²	Polymer Required	Odors	Batch or Continuous
 Gravity	Established	Ovivo, Ion Exchange	2%–15% (depends on residence time)	Large	Yes	Yes	Low	Unknown	None	Not contained	Continuous or batch
 Gravity Belt	Established	BDP Industries, Komline-Sanderson, Bellmer	4%–7%	Moderate	Unknown	Unknown	Moderate	Unknown	Low: 1.5–6 kg/ton dry solids	Not contained ³	Continuous
 Metal Screen	Emerging	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
 Rotary Drum (Vacuum Filtration)	Established	Parkson, PWTech	4%–10%	Small	Unknown	Unknown	Moderate	Unknown	Moderate	Contained	Continuous
 Dissolved Air Flotation	Established (with adaptations emerging)	Evoqua, WesTech, FRC	2%–5% (6%–10% using anoxic gas)	Large	Yes. But not suitable for FS with high-density solids	Unknown	Low	Unknown	Moderate	Not contained (but reduced with anoxic gas)	Continuous
 Membrane Filtration	Established	Ovivo	4%	Small	Yes, although mostly used for waste activated sludge.	Unknown	High	Unknown	None	Not contained ³	Continuous
 SLG	Emerging	Orge	Increases dryness of dewatering technologies by +3% to +8%	Small	No	Unknown	Unknown	Unknown	Yes. Quantity Unknown	Contained	Unknown

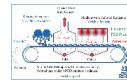
Mechanical Sludge Dewatering: Overview of Common Technologies

Dewatering Technology	Established or Emerging	Technology Vendors	Outlet Cake Solid (%)	Footprint	Experience with FS	Suitable for large volume	Capital Cost ¹	20-Year Lifecycle Cost ²	Polymer Required	Odors	Batch or Continuous
 Belt Filter Press	Established	Alfa Laval, Bilfinger	15%–18%	Small: <50 m ²	Yes	Yes	Moderate: \$200K–\$250K	\$2.5M	Moderate: 4.5 kg / ton dry solids	Not contained ³	Continuous
 Screw Press	Established	Huber, Alfa Laval, Bilfinger, Benenv	18%–20%	Small: <50 m ²	Yes	Yes	Moderate: \$250K–\$550K	\$10.4M	High: 15 kg/ton dry solids	Contained	Continuous
 Centrifuge	Established	Hiller, GEA, Alfa Laval	20%	Small: <50 m ²	Yes	Yes	Low: \$25K–\$60K	\$4.4M	Low: 2–3 kg /ton dry solids	Contained	Continuous
 Volute Press	Established	SBS AMCON	16%–30% (for well-digested sludge)	Small: <50 m ²	Yes	Yes	Moderate: \$40K–\$165k	\$2.9M	Moderate: 5–7 kg / ton dry solids	Contained	Continuous
 Rotary Press	Established	Prime Solutions, Fournier	20%–44%	Small: <50 m ²	Yes	Yes	Moderate: \$220K–\$450K	\$1.7M	Low: 2–4 kg /ton dry solids	Contained	Continuous
 Membrane Filter Press	Established	Andritz, PP Filter, Alfa Laval, Evoqua	35%–50%	Small: <50m ²	Unknown	Yes	Low to Moderate: \$40K–\$220K	\$2.2M	High: Unknown	Not contained ³	Batch
 Electro Dewatering	Emerging	Ovivo, Siemens	25%–45%+	Small: Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Contained and improved	Semi-continuous
 Bucher Hydraulic Press	Emerging	Bucher Hydraulics	Unknown	Small: Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Contained	Batch
 Salsnes Mechanical Filtration	Established	Salsnes Filter	20%–30%	Small: 60m ² –1,000m ²	No	Yes	Low: \$86,355 for 800 m ³ /day	Unknown	None	Contained	Continuous
 Solid-Liquid-Separation	Emerging	Agaeventure Systems	10%–20% solids or a paste material	Very Small: Pilot ≤ 1m ²	No	No (industrial application underway)	\$250,000 (pilot)	Unknown	None	Contained	Continuous

Passive Sludge Dewatering: Overview of Common Technologies

Dewatering Technology	Established or Emerging	Technology Vendors	Outlet Cake Solid (%)	Footprint	Experience with FS	Suitable for large volume	Capital Cost ¹	20- Year Lifecycle Cost ²	Polymer Required	Odors	Batch or Continuous
 Box Dewatering	Unknown	Park Process	Unknown	Very small	Unknown	Unknown	Unknown	Unknown	System dependent	System dependent ³	Batch
 Geotextile Bags	Established	Tencate, DRM Industrial Fabrics	20%+ (depends on residence time)	Large: ~0.5 acres	Yes	No	Moderate: Site Dev. + bags @ \$20–\$37.50 / linear ft.	Unknown. Bag costs is expected to be significant (~\$250K)	Yes	Contained	Batch
 Covered Drying Bed @ 20% TS	Established	N/A	20%	Large: 0.7 acres	Yes	Yes	Moderate: \$210K–\$235K	\$840K	Optional	Not contained	Batch
 Covered Drying Bed @ 45% TS	Established	N/A	45%	Very large: 8.0 acres	Yes	Yes (but significant land)	High: \$2.6M–\$2.9M	\$3.7M	Optional	Not contained	Batch
 Covered Drying Bed @ 60% TS	Established	N/A	60%	Very large: 9.5 acres	Yes	Yes (but significant land)	High: \$3M–\$3.5M	\$4.2M	Optional	Not contained	Batch

Thermal Sludge Drying: Overview of Common Technologies

Thermal Drying Technology	Established or Emerging	Technology Vendors	Outlet Cake Solid (%)	Footprint	Experience with FS	Suitable for large volume	Capital Cost ¹	20- Year Lifecycle Cost ²	Polymer Required	Odors	Batch or Continuous
 STC Thermal Drying	Emerging	Aqualogy	75-92%	Small: ~60m ²	No	Yes	Dependent on size and energy recovery system. \$600K- \$4.8M	Unknown	None	Contained	Continuous
 LaDePa	Emerging	PSS/UKZN	80%	Small: <502	Yes	Unlikely, although systems could be installed in parallel	Unknown	Unknown	No	Contained	Continuous

Note: Numerous other thermal drying technologies exist but were not originally the focus of this analysis. The STC drying system was included because it was identified by Isle Consulting as an emerging technology of interest. LaDePa was included due to the publication of key findings by BMGF partners.

¹Where provided, capital costs of mechanical systems reflect those obtained through primary research for capacities ranging from 250 to 1000 m³/ day. Small-capacity systems were not evaluated through the course of this analysis. Drying bed capex assumes climate conditions in India, that beds are covered with a simple overhang, incoming TS of 2.3%, 734 m³/day, and stated TS outputs. A capex range of \$80-\$90/m² of installed capacity was assumed based on data from Dakar and India.

²Lifecycle costs assume the following: 10-year lifespan for mechanical dewatering systems, 20-year lifespan for drying beds; labor cost = \$1.2 /hr, 310 operating days/year, Polymer price = \$7.4/kg, Electricity price = \$0.10/ kWh, Water price = \$0, Discount rate = 5%. Capex for mechanical systems are based on 1,000 m³/day of installed capacity, while Opex is based on a daily throughput of 734 m³ at 1%-2% TS. Drying bed lifecycle costs assume a 20-year lifespan, 734 m³/day design capacity and throughput, and 2.3% TS content. No upfront thickener is assumed in any scenario.

³ While some small-footprint mechanical systems do not contain odors, because of their small size, they can be installed inside a small structure, thereby eliminating odors.

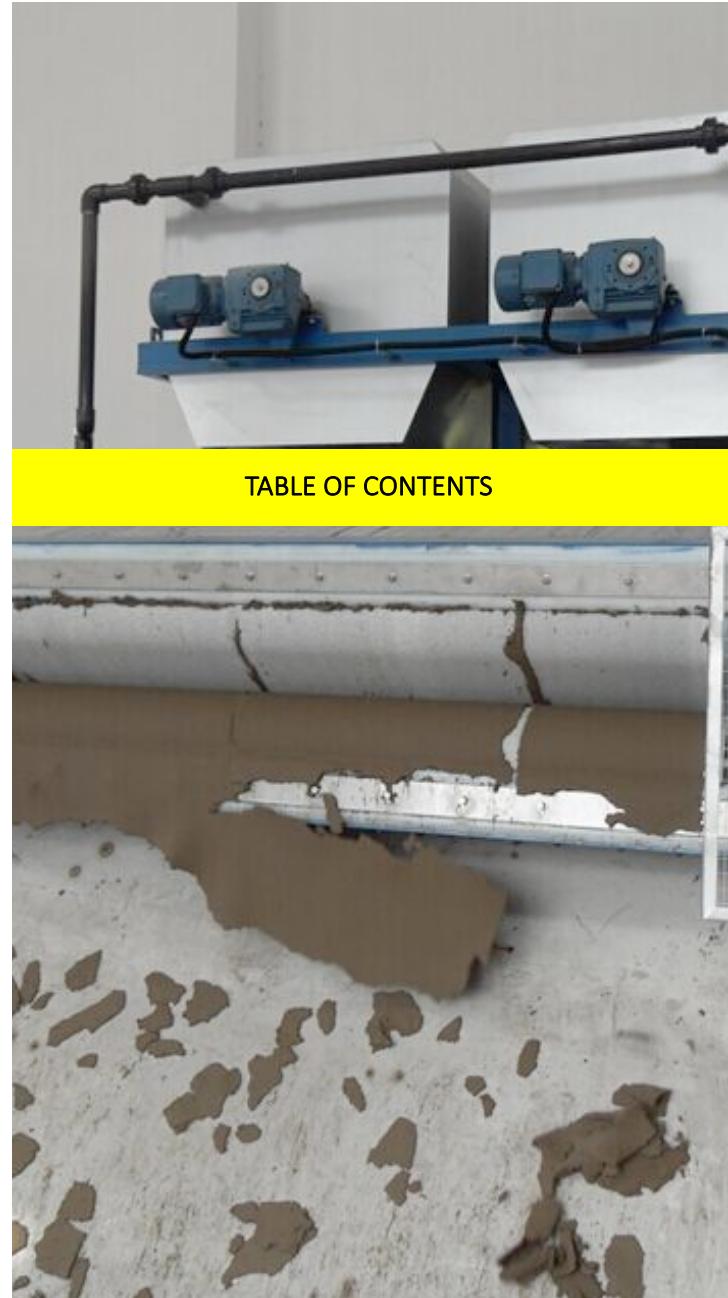


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Thickening Technology: Gravity Thickening

Technology Description: A gravity thickener is one of the easiest and cheapest methods for thickening sludge. It is a settling tank that concentrates solids by gravity-induced settling and compaction. Gravity thickeners are typically used to thicken primary solids and can be used without any chemical additions. They consist of a rectangular or circular tank with a sloped floor. Gravity thickeners can be operated in continuous or batch operation and are favored for their flow equalization and storage capacities. Overflow rate is the rate at which water moves out of the tank and can range from 0.2 to 0.4 liters per second per square meter. Gravity thickeners require significant space and settling time and are unlikely to be an appropriate technology for a mobile dewatering operation.

PARAMETER		PERFORMANCE
	Status	Established
	Odors	Not contained
	Batch or Continuous	Continuous or batch
	Expected Solids	Low: 2%–15%, depending on residence time
	Footprint	Large
	Capital Cost	Low
	Electricity Usage	Low: 0–20 kWh/metric ton of solids
	Wash Water	Unknown
	Labor and Operation	Very low
	Polymer Requirement	None
	Maintenance	Simple operation and maintenance; cyclic operations
	Experience with FS	Yes
	Suitable for Large Volumes	Yes

Source: Intellectual Ventures, 2017; STeP

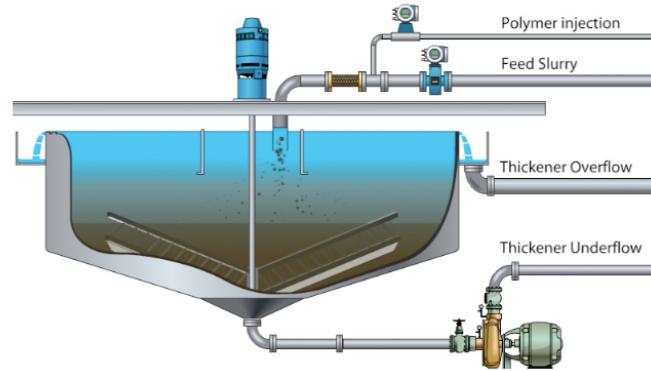


Figure: Gravity Thickening Tank—Source: ION India Limited

Thickening Technology: Gravity Belt Thickening

Technology Description: Gravity belt thickeners (GBTs) operate by laying sludge on a porous horizontal belt, while free water drains by gravity. The feed rate is a key operational control for GBT processes and it is typically at or below 10 liters per second for each meter of belt width. GBT is heavily reliant on polymer dosing but has a relatively small footprint.

PARAMETER	PERFORMANCE
	Status
	Odors
	Batch or Continuous
	Expected Solids
	Footprint
	Capital Cost
	Electricity Usage
	Wash Water
	Labor and Operation
	Polymer Requirement
	Maintenance
	Experience with FS
	Suitable for Large Volumes

Source: Intellectual Ventures, 2017; Sludge Management. Bhola R. Gurjar, Vinay Kumar Tyagi . CRC Press 2017; STeP

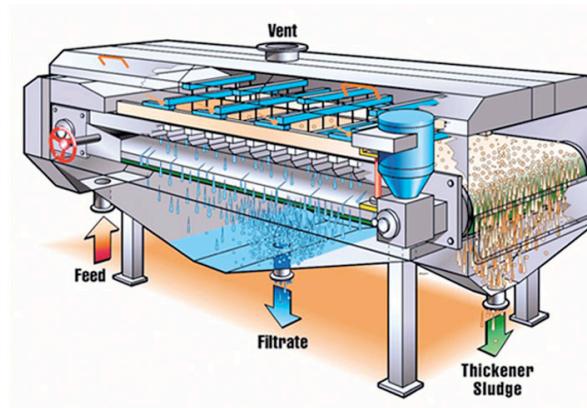


Figure: Gravity Belt Thickener—Source: BDP Industries

Thickening Technology: Metal Screen Thickening

Technology Description: Sludge thickening with metal screens is a new technology that has been previously piloted but has no full-scale operations. The system uses a set of slit screens that are installed in a mixing tank. Thickening occurs by low-pressure cross-flow filtration through the screens. The screens feature sub-millimeter openings.

PARAMETER	PERFORMANCE	
	Status	Emerging
	Odors	Unknown
	Batch or Continuous	Unknown
	Expected Solids	Unknown
	Footprint	Unknown
	Capital Cost	Low
	Electricity Usage	Unknown
	Wash Water	Unknown
	Labor and Operation	Moderate
	Polymer Requirement	Unknown
	Maintenance	Unknown
	Experience with FS	Unknown
	Suitable for Large Volumes	Unknown

Source: Intellectual Ventures, 2017



Figure: Metal Screen used for Sludge Thickening—Source: Huber

Thickening Technology: Rotary Drum (Vacuum Filter)

Technology Description: A rotary drum thickener—or a rotary vacuum-drum filter—consists of a rotating drum covered with cloth or other semi-porous textile. The drum is submerged in a slurry, or sludge, and sucks solids onto the surface of the textile while rotating out of the liquid/solid mixture. The vacuum continues to dewater the caked solids on the drum until they are discharged before the drum re-enters the liquid/solid slurry. The drum is rotated with a variable-speed drive that is usually operated between 5 and 20 rpm.

PARAMETER		PERFORMANCE
	Status	Established
	Odors	Contained
	Batch or Continuous	Continuous
	Expected Solids	Low: 4%–10%, depending on residence time
	Footprint	Small
	Capital Cost	Moderate
	Electricity Usage	10–30 kWh/metric ton of solids
	Wash Water	Requires wash water for drum cleaning
	Labor and Operation	Can require significant operator attention
	Polymer Requirement	Moderate
	Maintenance	Unknown
	Experience with FS	Unknown
	Suitable for Large Volumes	Unknown

Source: Intellectual Ventures, 2017; STeP

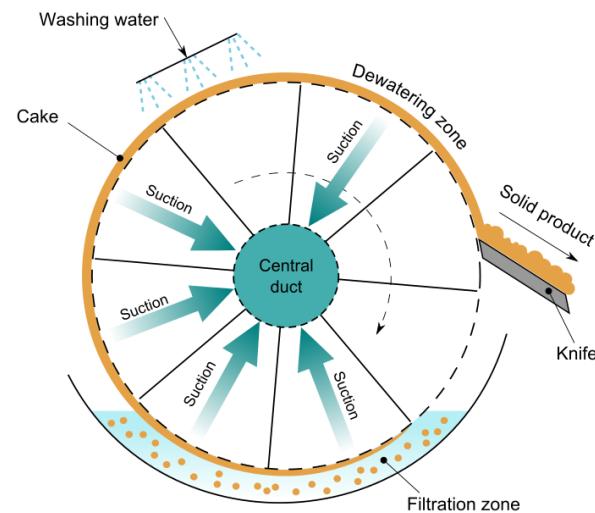


Figure: Rotary vacuum-drum filter – Source: [Wikipedia Commons](#)

Thickening Technology: Dissolved Air Flotation

Technology Description: Dissolved Air Flotation (DAF) thickening reduces the specific gravity of solids in FS to less than that of water by attaching microscopic air bubbles to suspended solids. The flocculated particles then float to the surface of the tank and are removed by skimming. It can achieve 2%–5% TS in the thickened sludge with only moderate polymer dosing. However, DAF is a clarification process not suitable for sludge with high-density solids. Gravity thickeners are generally used for primary sludge instead of DAF because of better performance with variable or primary sludge. **Flotation – Anoxic Gas (Recuperative Thickening):** Using anoxic gas in DAF thickening processes has been applied as a supplemental process to increase the speed of anaerobic digesters. In pilots, it achieved 6%–10% solids concentration in the final product. The process involves removing digested biosolids from an anaerobic digestion process, thickening with anoxic gas, and then returning it to the digestion process. It also has been shown to have better odor control than traditional flotation thickening.

PARAMETER	PERFORMANCE
	Status
	Established (with Anoxic Gas: Emerging)
	Odors
	Not contained (but reduced with Anoxic Gas)
	Batch or Continuous
	Continuous
	Expected Solids
	Low: 2%–5% (6%–10% with anoxic gas)
	Footprint
	Large
	Capital Cost
	Low
	Electricity Usage
	Unknown
	Wash Water
	Unknown
	Labor and Operation
	Low
	Polymer Requirement
	Moderate
	Maintenance
	Experience with FS
	Unknown; gravity thickeners are known to perform better with variable sludge
	Suitable for Large Volumes
	Unknown

Source: Intellectual Ventures, 2017; STeP

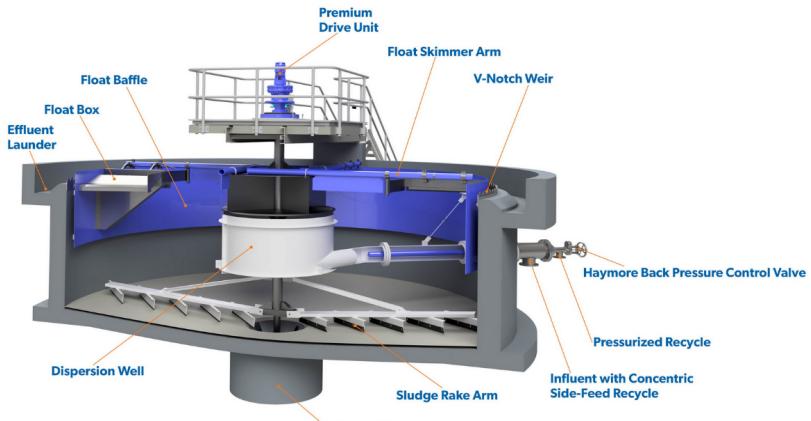


Figure: DAF System—Source: WesTech

Thickening Technology: Membrane Filtration

Technology Description: Membrane filtration can be used for thickening or dewatering and is similar to membrane bioreactors (MBR), which are widely used in the wastewater-treatment industry for activated sludge treatment. Membrane units are submerged in a basin with suspended biomass and create a barrier for the solid-liquid separation. There are many different suppliers of both off-the-shelf and custom membrane systems. Some of the different types of membrane configurations include tubular, hollow-fiber, spiral wound sheets, plate and frame, and pleated-cartridge filters. Thickening up to 4% solids has been reported for FS, though an aerobic environment is required for non-activated sludge.

PARAMETER		PERFORMANCE
	Status	Established
	Odors	Not contained
	Batch or Continuous	Continuous
	Expected Solids	Low: 4%
	Footprint	Small
	Capital Cost	High
	Electricity Usage	Unknown
	Wash Water	Unknown
	Labor and Operation	Moderate
	Polymer Requirement	None
	Maintenance	Complicated maintenance and operation
	Experience with FS	Yes
	Suitable for Large Volumes	Unknown

Source: Intellectual Ventures, 2017; STeP



Figure: Ceramic Membrane in Sludge Thickening Application—Source: Ovivo

Thickening Technology: SLG

Technology Description: The SLG is a patented technology that conditions municipal and industrial sludge by breaking colloids using super pressurized air. It then uses a flocculant to agglomerate the de-constructed colloids, increasing the dry-solid content of the dewatered sludge and decreasing the volume of sludge by a factor of 2 to 3. The SLG is a compact technology that can be installed ahead of traditional dewatering technologies to increase their performance. Currently, Orege is preparing an installation on an industrial biological wastewater-treatment plant. In this case, the SLG is expected to increase the TS content from 15% to 30%. They have also developed a mobile unit with the capacity of treating 1–20 m³/hour with a power requirement of 15 KW.

PARAMETER	PERFORMANCE
	Status
	Odors
	Batch or Continuous
	Expected Solids
	Footprint
	Capital Cost
	Electricity Usage
	Wash Water
	Labor and Operation
	Polymer Requirement
	Maintenance
	Experience with FS
	Suitable for Large Volumes

Source: Isle Consulting; STeP



Figure: Orege Mobile Thickening Unit, SLG—Source: [LinkedIn](#)

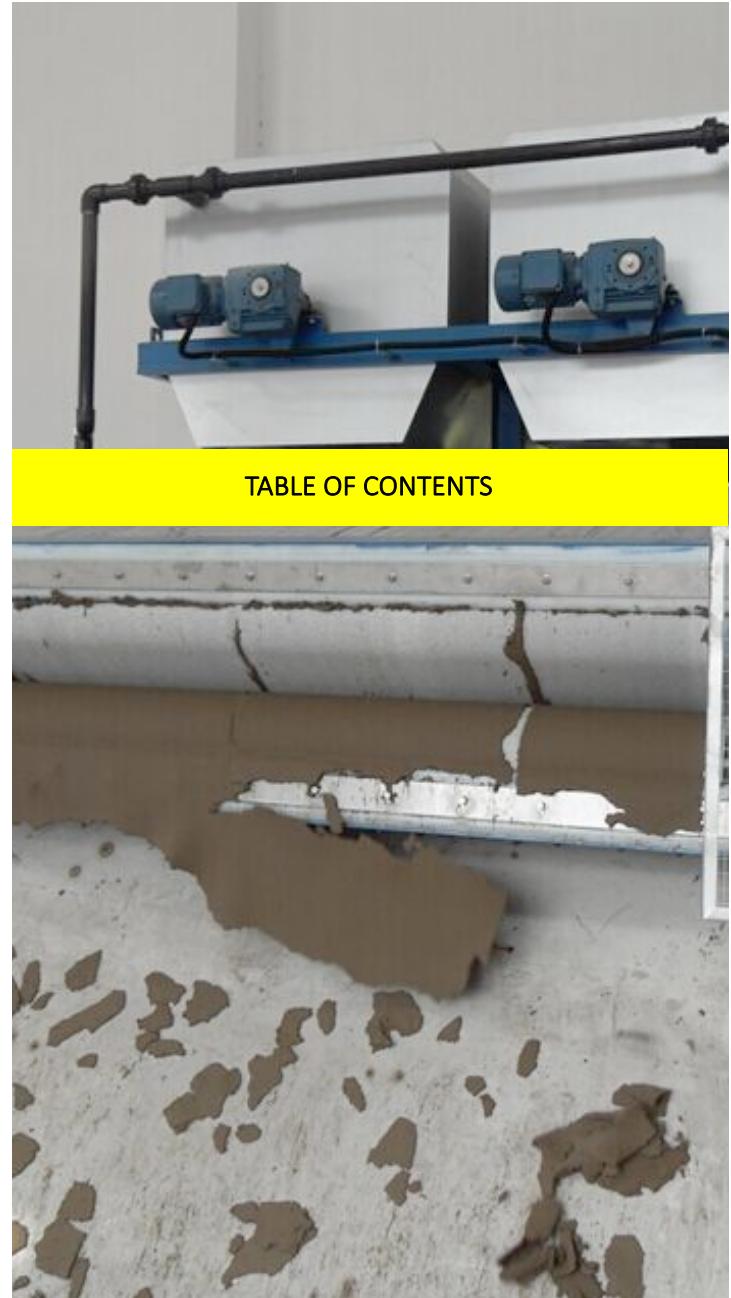


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Dewatering Technology: Belt Filter Press

Technology Description: Belt filter presses use a combination of gravity drainage and compression to dewater sludge. The first stage of a belt filter press is similar to a gravity belt thickener, where sludge is conditioned with polymers then placed on a porous horizontal belt that allows free water drainage. The second stage further dewater the sludge by compressing the sludge between two porous belts and applying pressure and shear force through rollers. Belt filter presses that are dewatering raw primary sludge usually operate at 2 to 5 liters per second for every meter of belt width. Advances in belt filter press technology include the use of 3 belts and using larger rollers for applying gentle pressure when dealing with smooth sludge.

PARAMETER	PERFORMANCE
	Status
	Odors
	Batch or Continuous
	Expected Solids
	Footprint
	Capital Cost
	Moderate: \$200K for 250 m ³ /day to \$250K for 1,000 m ³ /day
	Electricity Usage
	Medium: 140–700 Wh/m ³ of sludge
	Wash Water
	High: more than 400 L/m ³ of sludge
	Labor and Operation
	Low: less than 2 hours per day
	Polymer Requirement
	Moderate: 4.5 kg/ ton dry solids
	Maintenance
	Moderate: frequent but straightforward maintenance of many moving parts; can be difficult to clean
	Experience with FS
	Yes; very sensitive to sludge properties
	Suitable for Large Volumes
	Yes

Source: Intellectual Ventures, 2017; STeP: Primary research with technology vendors. Expected solids based on primary research although literature sources suggest solids content could be higher with pre-thickened sludge.



Figure: Belt Filter Press—Source: Alfa Laval

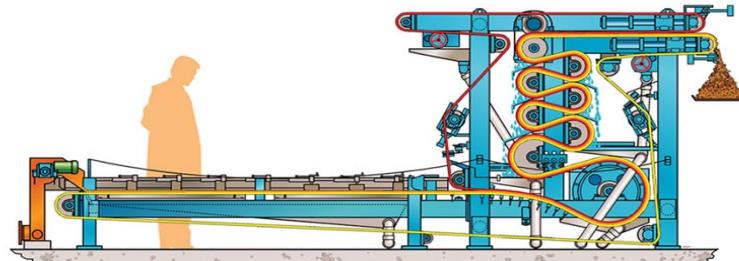


Figure: Belt Filter Press—Source: BDP Industries

Dewatering Technology: Screw Press

Technology Description: The screw press is a relatively new technology in the sludge dewatering field. It was developed in the pulp/paper industry. Compared with other mechanical dewatering technologies, it is a simple, low maintenance system. The slow rotational speed results in less noise than centrifugation and will reduce the costs of long-term maintenance. Screw press designs include both horizontal and inclined configurations. Typical input flow rates are between 1 and 5 liters per second.

PARAMETER	PERFORMANCE
	Status
	Odors
	Batch or Continuous
	Expected Solids
	Footprint
	Capital Cost
	Moderate: \$200K for 250 m ³ /day to \$550K for 1,000 m ³ /day
	Electricity Usage
	Low: 140 Wh/m ³ of sludge
	Wash Water
	Medium: 8 L/m ³ sludge
	Labor and Operation
	Medium: less than 2 hours per day labor but other chemicals required. Fully automated operation.
	Polymer Requirement
	High: 15 kg/ton dry solid
	Maintenance
	Moderate: greasing bearings, replacing internal wiper every 6 months; reduced noise and vibration
	Experience with FS
	Yes
	Suitable for Large Volumes
	Yes

Source: Intellectual Ventures, 2017; STeP: Primary research with technology vendors.

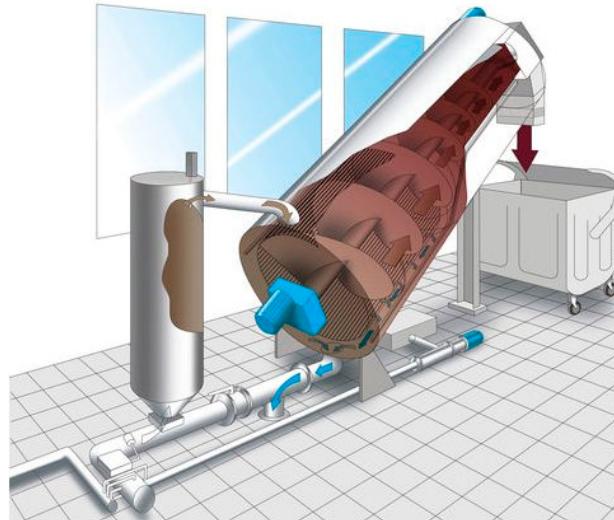


Figure: Inclined Screw Press—Source: Huber

Dewatering Technology: Screw Press (Truck Mounted)

Technology Description: Benenv has developed a compact, mobile sludge dewatering system based on a scaled down mixing plus flocculation tank followed by a screw press. The development of this technology was funded by the Government of China to reduce hauling costs associated with fecal sludge transport. The CDS-312 model has a throughput of 100-200 kg dissolved solids / hour. The truck-mounted unit can reportedly reduce sludge disposal volume by 1/3, and remove 99% of suspended solids, 98.5% of BOD and 99.7% of COD from the filtrate.

PARAMETER	PERFORMANCE
	Status Emerging
	Odors Contained
	Batch or Continuous Continuous
	Expected Solids 25%
	Footprint Low: Same as desludging truck area
	Capital Cost Unknown
	Electricity Usage Low: Amount unknown
	Wash Water Unknown
	Labor and Operation Truck drivers appears able to also operate dewatering unit.
	Polymer Requirement Yes but quantity unknown
	Maintenance Easy. Fully automated system with few wearing parts.
	Experience with FS Yes
	Suitable for Large Volumes No



Figures (Top to Bottom): Interior of mobile screw press;
Screw press contained inside – Source: Benenv

Dewatering Technology: Centrifuge

Technology Description: A centrifuge is a high-speed process that separates fecal solids from sludge through centrifugal force. They have been used in the wastewater treatment industry since the 1930s and are still a commonly used technology. Centrifuges are one of the most versatile of all sludge dewatering technologies, and their operation can be varied to thicken or dewater sludge to desired levels. They are able to operate within one of the smallest footprints, but they are also more complicated to operate and have one of the highest energy requirements.

PARAMETER		PERFORMANCE
	Status	Established
	Odors	Contained
	Batch or Continuous	Continuous
	Expected Solids	Low: 4%–20%
	Footprint	Low: less than 50 m ²
	Capital Cost	Low: \$25K for 250 m ³ /day to \$60K for 1,000 m ³ /day
	Electricity Usage	High: more than 1 k Wh/m ³ of sludge
	Wash Water	Medium: 14 L/m ³
	Labor and Operation	Very Low: less than 2 hours per day; requires skilled operators
	Polymer Requirement	Low: 2–3 kg/ton dry solids
	Maintenance	High: yearly maintenance by technician and 5-year scroll servicing; operations are noisy
	Experience with FS	Yes
	Suitable for Large Volumes	Yes

Source: Intellectual Ventures, 2017; STeP: Primary research with technology vendors.

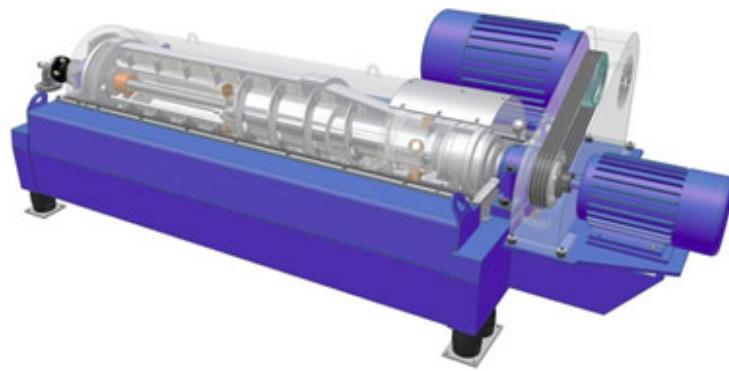


Figure: Two Phased Decanter—Source: Hiller

Dewatering Technology: Volute Press

Technology Description: The Volute Press® (a registered trademark of AMCOM, Inc. of Yokohama, Japan) consists of a central screw and slowly oscillating multi-disk filters to gradually increase pressure on the sludge. The technology combines flocculation, thickening, and dewatering, eliminating the need for additional equipment. The pitch of the screw narrows, and the gaps between the rings decrease towards the end-plate, where solids are discharged. Key features of the technology are that it is capable of processing dilute sludges with TS contents greater than 0.1%. The AMCOM technology has an automatic polymer feed system and a self-cleaning feature, enabling continuous operations. The Volute dewatering press comes in a variety of sizes suitable for smaller applications as well as large scale wastewater treatment plants. The process treatment capacity of the systems ranges from 0.3 to 90 m³/h but can vary depending on the waste characteristics.

PARAMETER	PERFORMANCE
	Status
	Odors
	Batch or Continuous
	Expected Solids
	Footprint
	Capital Cost
	Low to Moderate: \$40K–\$165k larger capacity systems
	Electricity Usage
	Low: 140–360 Wh/m ³ of sludge
	Wash Water
	Low: less than 1 L/m ³ of sludge
	Labor and Operation
	Very Low: less than 2 hours per day
	Polymer Requirement
	Medium: 5–7 kg/ton dry solids
	Maintenance
	Low: none required for at least 5 years except control electronics
	Experience with FS
	Yes
	Suitable for Large Volumes
	Yes

Source: STeP: Primary research with technology vendors; [PWTech](#); Isle Consulting

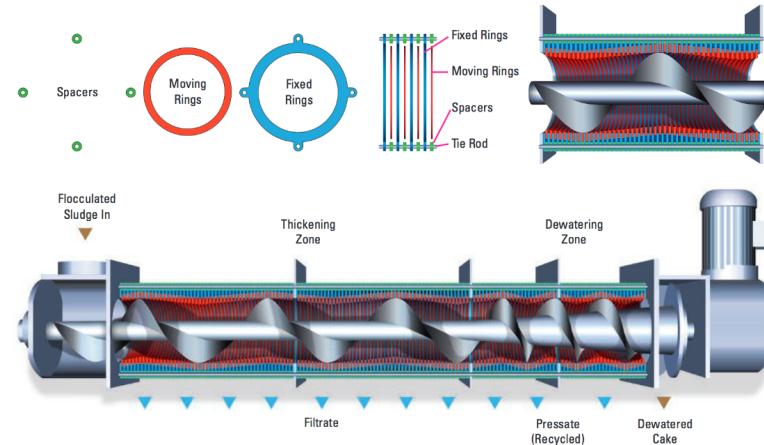


Figure: Volute Press—Source: PWTech

Dewatering Technology: Rotary Press

Technology Description: Sludge is fed at low pressure into the channels and rotates between two parallel revolving stainless steel, chrome-plated filtering elements. As free water passes through the screens, the sludge continues to dewater as it travels around the channel. The flocculated sludge builds up solids until enough pressure is generated against the outlet restricted arm. The frictional force of the slow-moving filtering elements, coupled with controlled outlet restriction, generates enough back-pressure to dewater the remaining solids, resulting in the extrusion of a very dry cake (Fournier). Technology vendors offer stationary and skid-mounted units.

PARAMETER	PERFORMANCE
	Status
	Odors
	Batch or Continuous
	Expected Solids
	Footprint
	Capital Cost
	Electricity Usage
	Wash Water
	Labor and Operation
	Polymer Requirement
	Maintenance
	Experience with FS
	Suitable for Large Volumes
	Established
	Contained
	Continuous
	High: 20%–44%
	Small: less than 50 m ²
	Moderate: \$220K for 250 m ³ /day to \$450K for 1,000 m ³ /day
	Medium: 150–500 Wh/m ³ of sludge
	Medium: 6–8 L/m ³ of sludge
	Very low: less than 2 hours per day.
	Low: 2–4 kg/ton dry solids
	Low: simple maintenance and shut down procedures; \$3,500–\$5,000 / year in parts replacement
	Yes, limited to North American applications
	Yes

Source: STeP: Primary research with technology vendors.



Figure: Rotary Press—Source: Fournier

Dewatering Technology: Chamber Press and Membrane-Filter Press

Technology Description: In a chamber press, the sludge to be dewatered is injected into the center of the press, and each chamber is filled in turn. Then the liquid portion of the sludge is filtered out through textile media by adding streams of compressed air or water. Chamber presses have been most widely used for dewatering mining slurries, but have been widely applied to other industries. They are typically only operated in batch processes and are a relatively slow method of dewatering. The membrane-filter press is a further development of the chamber press. It is reported to have shorter filter times than a chamber filter press, along with higher final solids content.

PARAMETER	PERFORMANCE
	Status
	Odors
	Batch or Continuous
	Expected Solids
	Footprint
	Capital Cost Moderate: \$40K–\$100K for 250 m ³ /day; \$75K–\$220K for 1,000 m ³ /day (Manufacturer dependent)
	Electricity Usage
	Wash Water
	Labor and Operation
	Polymer Requirement
	Maintenance
	Experience with FS
	Suitable for large volumes



Figure: Membrane Filter Press—Source: Fournier

Dewatering Technology: Electro Dewatering

Technology Description: Electro dewatering processes combine electro-osmosis and mechanical pressure to dewater sludge. It is a newer dewatering technology with only a few suppliers. It has been reported to have the added benefit of pathogen reduction due to the electric field. Electroacoustic dewatering has been tested at the bench scale. Electro dewatering is a secondary drying technology that is typically used after a traditional mechanical system, such as a belt filter press or a centrifuge. Tests report that solids contents were increased by 3.4% to 10.4%, although some pilots are known to have achieved cake solids concentrations of 50%–70%.

PARAMETER	PERFORMANCE
	Status
	Odors
	Batch or Continuous
	Expected Solids
	Footprint
	Capital Cost
	Electricity Usage
	Wash Water
	Labor and Operation
	Polymer Requirement
	Maintenance
	Experience with FS
	Suitable for Large Volumes

Source: Intellectual Ventures, 2017. Siemens conducted a pilot study in which it first dewatered solids to 20%–27% TS using a centrifuge, followed by electro dewatering using the SELO-500 to achieve cake solids of 50%–70%.

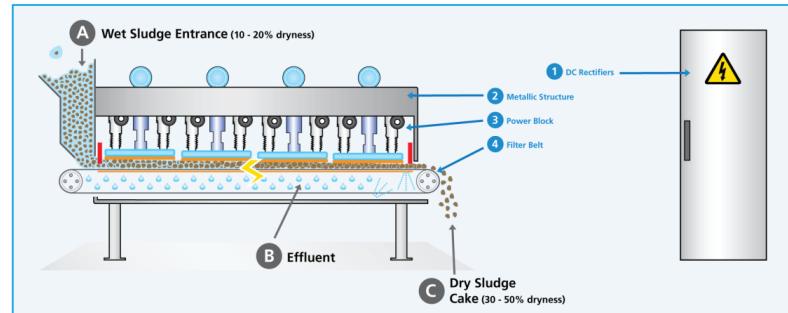


Figure: Electro dewatering – Source: TreatmentEquipment.com

Dewatering Technology: Bucher Hydraulic Press

Technology Description: Bucher Unipektin manufactures a hydraulic dejuicing press that has been tested on biosolids in limited environments. The press consists of a cylinder and a moving piston that squeezes the sludge while free water passes through porous cloth filter elements. It can obtain 25% more total solids than a belt filter press but is a batch process.

PARAMETER	PERFORMANCE
	Status
	Odors
	Batch or Continuous
	Expected Solids
	Footprint
	Capital Cost
	Electricity Usage
	Wash Water
	Labor and Operation
	Polymer Requirement
	Maintenance
	Experience with FS
	Suitable for Large Volumes

Source: Intellectual Ventures, 2017



Figure: Bucher Filter Press – Source: [Bucher Unipektin](#)

Dewatering Technology: Salsnes Mechanical Filter

Technology Description: Salsnes Filter is a mechanical filtration system that has been used as a replacement for conventional primary sludge treatment in wastewater plants. Three processes are performed in one compact unit: solids separation, sludge thickening, and sludge dewatering. Waste is processed through a polyethylene mesh, where solids are separated; the particles collected on the mesh undergo a drying process through the Air Knife (compressed air) that starts automatically when the mesh begins to rotate. This is applied both to perform sludge pre-treatment by drying the particles for more efficient consequent sludge de-watering and to clean and preserve the mesh. The Salsnes Filter is covered by multiple patents.

PARAMETER	PERFORMANCE
	Status
	Contained
	Batch or Continuous
	Expected Solids
	Footprint
	Capital Cost \$86,355 for 800 m³/day Electricity Usage 0.02–0.15 kWh/m³ of sludge Wash Water 100 liters/day at 4–6 bar pressure Labor and Operation Unknown; nominal labor, electricity, water Polymer Requirement None Maintenance 1 hr/week: each unit is equipped with control system for fully automated operation. \$685–\$1370/yr for spare parts.
	Experience with FS No Suitable for Large Volumes Yes, systems range from 800–8,000 m³/day ¹

Source: Isle Consulting ¹Based on treatment of municipal wastewater with TSS ranging from 250–500 mg/l

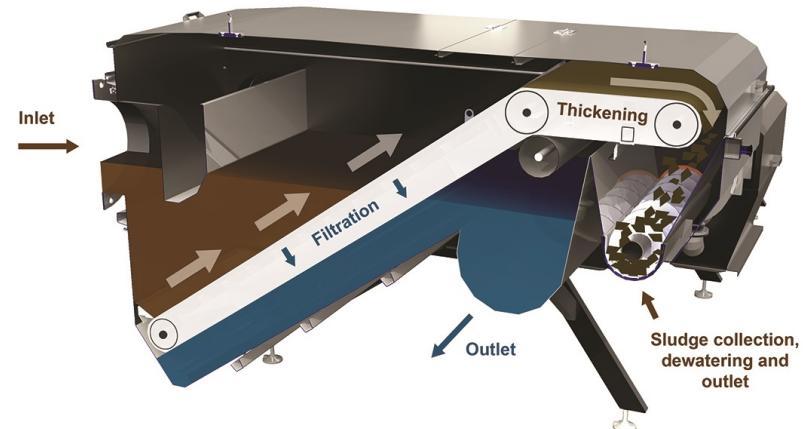


Figure: Salsnes Mechanical Filter—Source: Salsnes Filter

Dewatering Technology: Solid Liquid Separation

Technology Description: The Solid-Liquid-Separation (SLS) system is an innovative process for separating micro-solids from solutions, dramatically reducing energy consumption by using surface physics and capillary action. The system consists of two belts moving in opposite directions. The top belt carries the solution (allowing water to drain through the belt) and the capillary belt moving in the opposite direction passes directly underneath. The capillary belt is wetted, further helping water to draw through the top belt using liquid adhesion. Unlike the majority of filtering technologies that are meant only to remove particles from a liquid stream, the SLS is uniquely designed to harvest the particles. The SLS system currently comes in Lab and Pilot models, with the Industrial model under development.

PARAMETER		PERFORMANCE
	Status	Emerging
	Odors	Contained
	Batch or Continuous	Continuous
	Expected Solids	10% to 20% solids or a paste material
	Footprint	Small: pilot occupies less than 1 m ² (for up to 500 L/h; however, capacity is dependent TS content and other solution characteristics)
	Capital Cost	Moderate: Pilot Model system costs \$250,000
	Electricity Usage	0.025 kWh/Kg dry weight
	Wash Water	None
	Labor and Operation	No Data
	Polymer Requirement	None
	Maintenance	Low maintenance is required, and the main consumable items within the system are the belts
	Experience with FS	No
	Suitable for Large Volumes	Unknown

Source: Isle Consulting

The SLS system is currently used for AVS' in-house algae dewatering needs but could potentially be adapted to dewater sludge with additional investment.

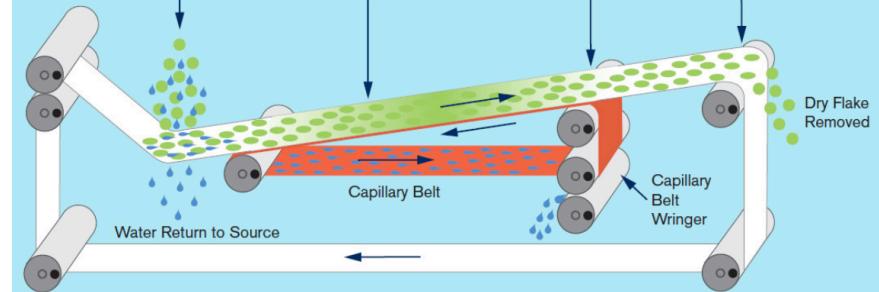


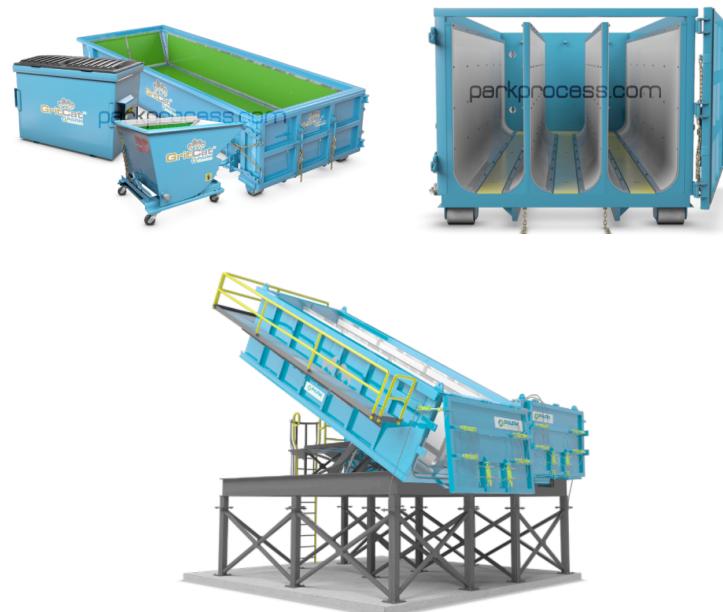
Figure: SLS Process Diagram—Source: Algaeventures Systems

Dewatering Technology: Box Dewatering

Technology Description: Park Process manufacturers a portfolio of dewatering boxes that are containerized and mobile. The boxes rely on gravity filtration through reusable plastic filter media. Specific product offerings include (1) the Sludge King; (2) the GritCat, designed to be used with gritty or sandy waste streams that typically do not require the use of a coagulant or flocculent for dewatering; (3) AquaCat, designed to be used with light gravity sludge and slurries made up of very fine particles that require the addition of a flocculent for effective; (4) GeoCat, designed to be used with sticky, slimy, slightly oily, non-uniform, non-specific, colloidal, or simply hard-to-dewater sludge where flocculation is not an option; and (5) the Big Tipper, which is a stationary, mounted unit. System performance is currently unknown.

PARAMETER	PERFORMANCE
	Status
	Odors
	Batch or Continuous
	Expected Solids
	Footprint
	Capital Cost
	Electricity Usage
	Wash Water
	Labor and Operation
	Polymer Requirement
	Maintenance
	Experience with FS
	Suitable for Large Volumes

Source: STeP secondary research, [Park Process](#)



Figures clockwise from top left: GritCat, Sludge King, Big Tipper
Source: [Park Process](#)



Dewatering Technology: Geotextile Bags

Technology Description: Geotubes® (Tencate) and Sedi—Filters (DRM) are geotextile tubes that comprise high-strength polypropylene fabric. The tube is pumped full of sludge, and the fabric retains fine-grain material while allowing effluent water to permeate through the tube wall. As the water is drained from the tube, additional sludge can be added. Once filled with dried solids, the material is removed, but the geotextile material cannot be reused. Drying can take 5–7 weeks to achieve 20% TS and 3–4 months to achieve 35%–40% TS. A significant footprint is required and the technology is unlikely to be compatible with a mobile dewatering scheme.

PARAMETER		PERFORMANCE
	Status	Established
	Odors	Contained
	Batch or Continuous	Batch
	Expected Solids	High: 20%+ (depends on residence time)
	Footprint	Medium: ~0.5 acre of bags, plus work areas
	Capital Cost	\$20–\$37.50 / linear ft. for bags; additional cost for site development and pumps
	Electricity Usage	Unknown: limited to electricity for pumping
	Wash Water	None
	Labor and Operation	High: continual bag replacement plus full-time operators and electricity for pumping equipment
	Polymer Requirement	Polymer required, but of unknown amount
	Maintenance	Low/None: sight maintenance only
	Experience with FS	Yes, although at much lower throughputs
	Suitable for Large Volumes	No, one expert noted, “one would not use Geotubes® for such large volumes” (e.g., more than 500m³/day)



Figure: Filled Geobags®—Source: GeoFabrics.co

Source: Intellectual Ventures, 2017; STeP: Primary research with technology vendors; Isle Consulting

Dewatering Technology: Drying Beds

Technology Description: Drying beds are a simple, low-tech means of dewatering sludge that function well in arid regions. Many types of drying beds require no energy, but all require large footprints and have very long residence times. There are many different types of drying bed technologies, such as mechanical freeze-thaw, auger-assisted, vacuum-assisted, and quick-dry filter beds. Each of these can achieve shorter residence time than traditional beds, but they usually require the addition of polymers or additional energy. All drying-bed technologies require significant land use.

PARAMETER	PERFORMANCE	
	Status	Established
	Odors	Not Contained
	Batch or Continuous	Batch
	Expected Solids	Variable (higher TS = larger footprint)
	Footprint	Less than 1 acre for low TS outputs; very large for TS content more than 20%
	Capital Cost	Low for ~20% TS; high for higher TS outputs. \$80–\$90 per m ² installed.
	Electricity Usage	None
	Wash Water	None
	Labor and Operation	Moderate: multiple full-time operators and equipment for emptying beds
	Polymer Requirement	Optional (increase solids capture rates)
	Maintenance	Low: sight maintenance only
	Experience with FS	Yes
	Suitable for large volumes	Yes, although significant land required due to long residence times

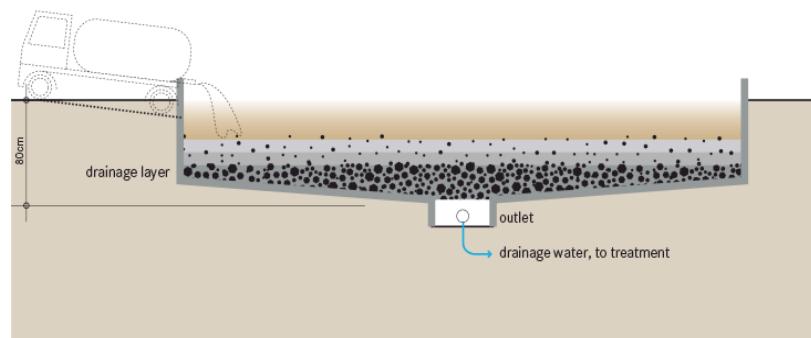


Figure: Unplanted Drying Bed—Source: TILLEY et al. (2014)

Source: STeP: Primary research with technology vendors. TILLEY, E.; ULRICH, L.; LUETHI, C.; REYMOND, P.; SCHERTENLEIB, R.; ZURBRUEGG, C. (2014): *Compendium of Sanitation Systems and Technologies (Arabic)*. 2nd Revised Edition. Duebendorf, Switzerland: Swiss Federal Institute of Aquatic Science and Technology (Eawag).

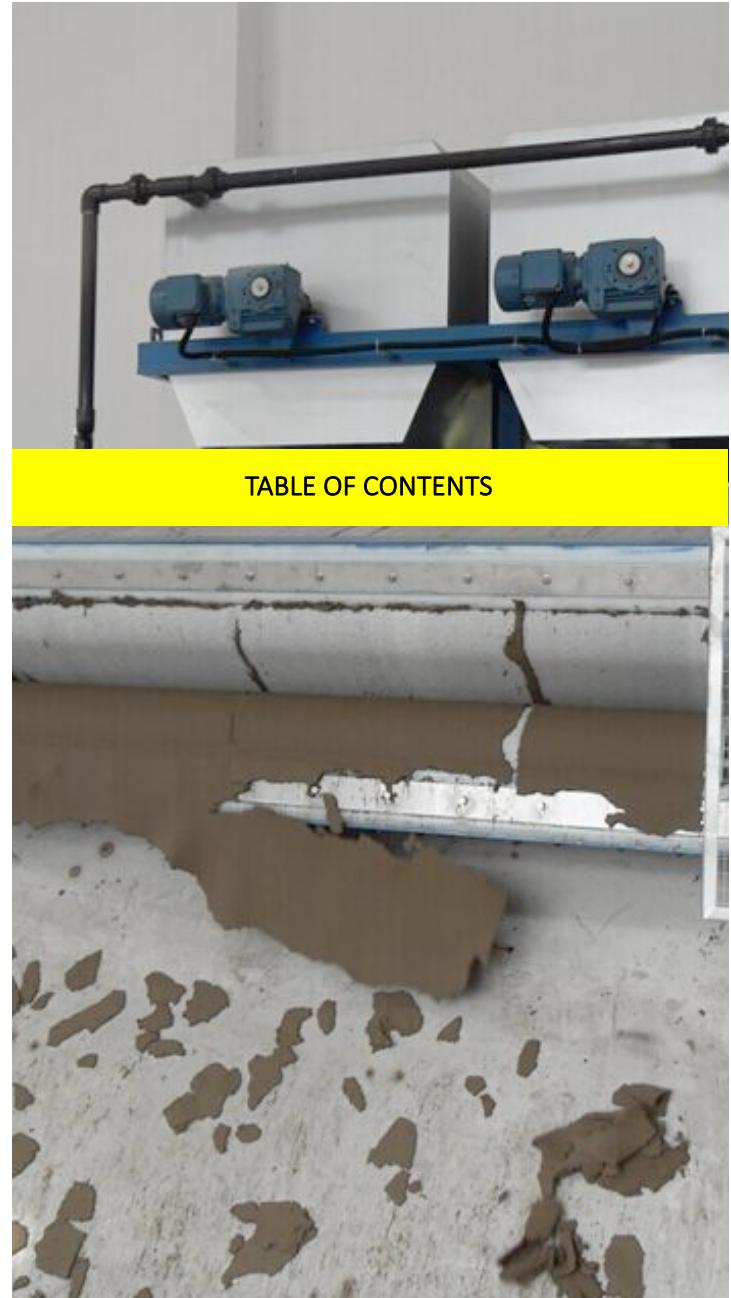


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Thermal Drying Technologies

Thermal Drying Technology: STC Thermal Drying

Technology Description: The STC thermal drying system uses low temperatures to dry mechanically dewatered sludges from 20% TS to between 75% and 92% TS. The first stage consists of a sludge extrusion system that produces strings of dewatered sludge. As the sludge travels along two consecutive belts, a fan system generates circular hot dry air movement at 65°–80°C. The sludge then passes through a crushing mill to produce homogenous pellets. The energy needed to heat the sludge and evaporate the water is recovered from the condensation process, maximizing the use of residual heat.

PARAMETER	PERFORMANCE
	Status
	Odors
	Batch or Continuous
	Expected Solids
	Footprint
	Capital Cost
	Electricity Usage
	Water
	Labor and Operation
	Polymer Requirement
	Maintenance
	Experience with FS
	Suitable for Large Volumes

Source: Isle Consulting

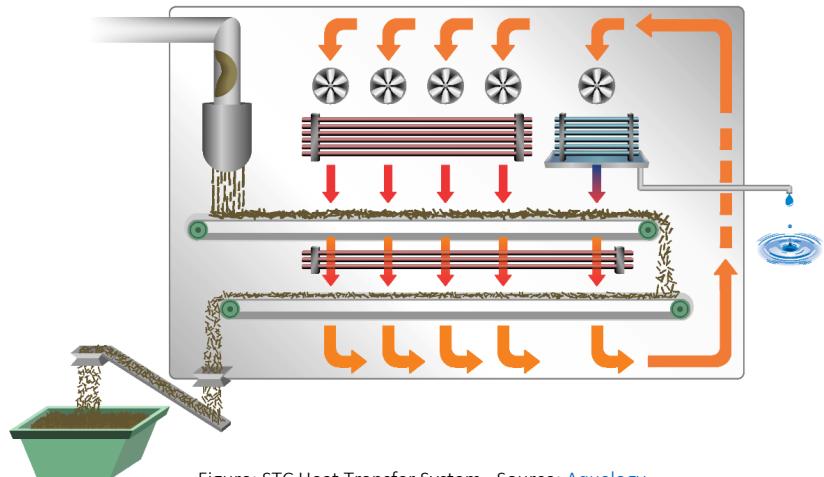


Figure: STC Heat Transfer System—Source: [Aqualogy](#)

Thermal Drying Technology: LaDePa

Technology Description: In this process, sludge is pelletized using a screw extruder and processed by a combination of infrared and convective drying. The final product is dried, pasteurized pellets that are safe to handle, with minimum exposure to pathogen risk. They can potentially be used in agriculture or as a biofuel. In a study conducted by the Pollution Control Group at UKZN, researchers found that pellets had characteristics for reuse; they have similar nutrient content to manure and compost and similar calorific value to wood. Radiation intensity and the source height largely affected the final product; thus, these two parameters need to be adjusted and optimized to achieve an appropriate product property for different applications. The system achieves complete inactivation of helminth eggs and pasteurization of fecal coliforms.

PARAMETER	PERFORMANCE
	Status
	Contained
	Batch or Continuous
	Expected Solids Target for full scale unit = 80%
	Footprint Small: system is containerized; less than 50m ²
	Capital Cost Unknown
	Electricity Usage 210 KW engine required
	Water Unknown
	Labor and Operation Two operators required, plus 15 liters/hr of diesel
	Polymer Requirement None
	Maintenance Unknown
	Experience with FS Yes
	Suitable for Large Volumes Unlikely; current capacity is 2,500 kg/day at 70% TS, but units could be installed in parallel

The Tongaat Wastewater Treatment Plant (WWTP) is home to the first full-scale LaDePa system. Additional units are reportedly being commissioned for other nearby WWTPs (Source: UKZN)

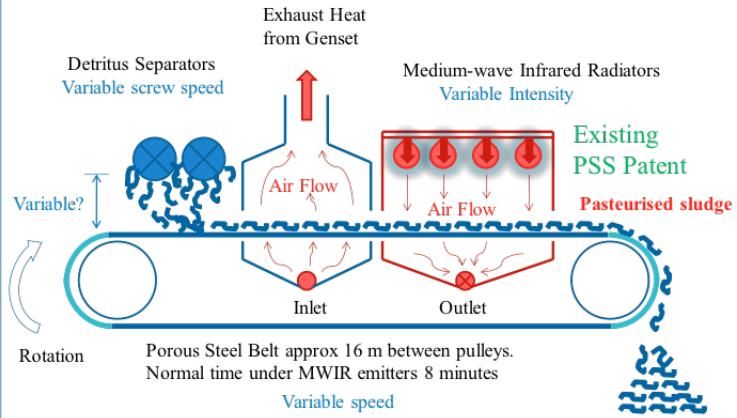


Figure: LaDePa Process – Source: [UKZN](#)

Source: 'LaDePa' process for the Drying and Pasteurisation of Faecal Sludge from VIP latrines by the means of IR radiation. Septien, S.*, Singh, A., Mirara, S.W., Teba, L., Velkushanova, K., Buckley, C. Pollution Research Group, University of KwaZulu-Natal, Durban 4041, South Africa; STeP secondary research.