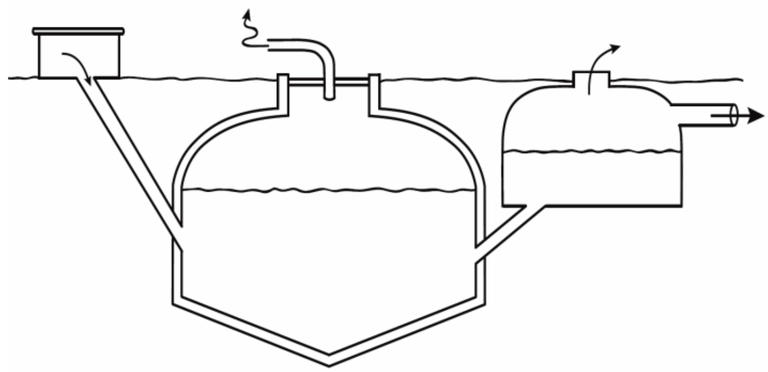
Anaerobic Digestion



Fixed dome anaerobic digester (Credit: CAWST)

Anaerobic digester under construction in Afghanistan (Credit: SuSanA)

- **Design:** Anaerobic digestion stabilizes faecal sludge. It converts fecal sludge into (1) biogas that can be used for energy, and (2) a slurry that can be used as fertilizer.
- **Operation:** Anaerobic digestion is operated (semi-) continuously. Faecal sludge goes in an airtight reactor. Microorganisms break down the organic material in faecal sludge in the absence of oxygen (anaerobic conditions). This process produces methane, also called biogas. Some part of the faecal sludge remains in the reactor following breakdown. This is called digestate and needs to be removed for continuous operation. Faecal sludge can be co-digested with organic material (like food waste and animal excreta) to increase the volume of biogas. Anaerobic digestion is a delicate process to operate, and can be easily upset.
- **Time and energy required:** Time and energy required is different depending on the reactor design.

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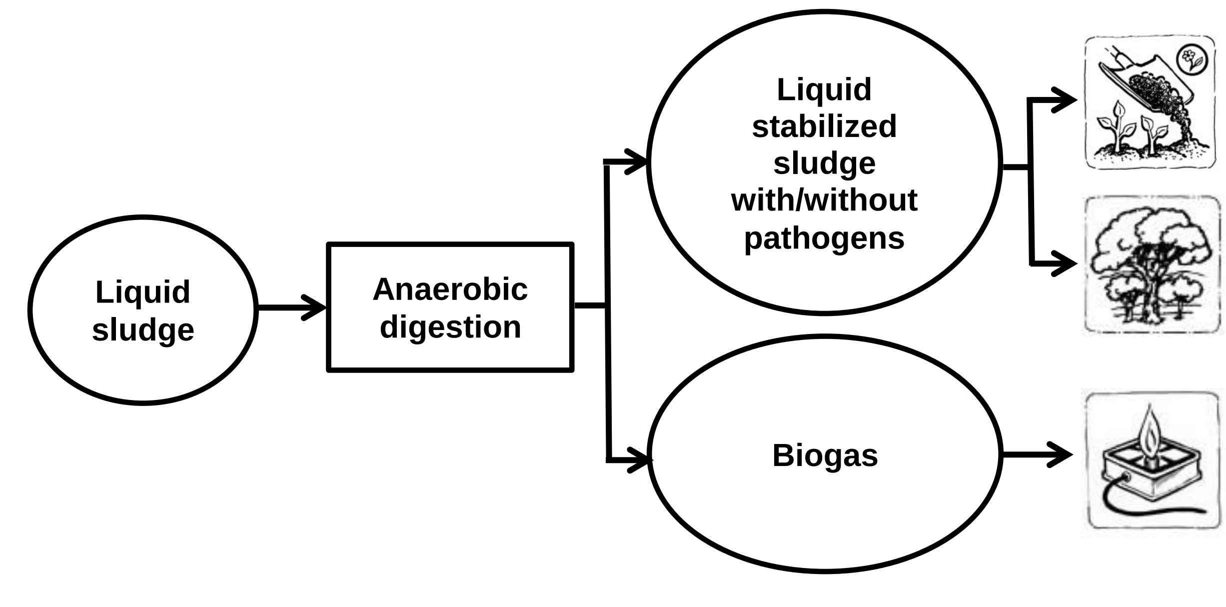
Treatment Technology Description



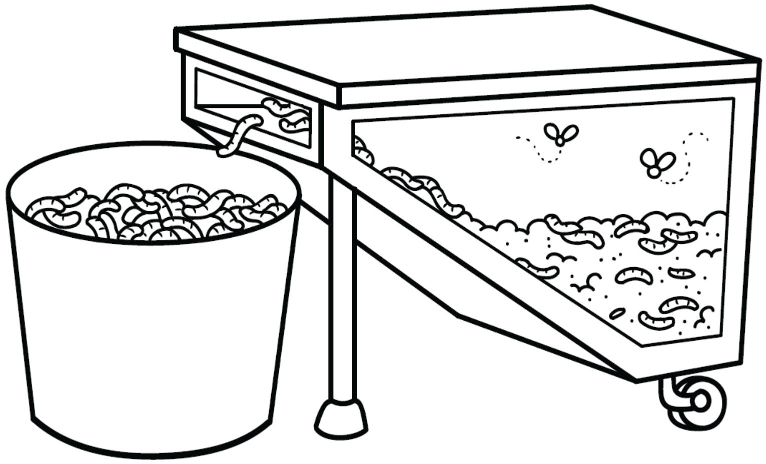
Treatment Objectives	Pathogen Inactivation	**Low**
	Dewatering	
	Stabilization/Nutrient Management	**Yes**
Pathogen Inactivation		• Pathogen inactivation depends on the operation of the anaerobic digester. Under thermophilic conditions, pathogens are inactivated by high temperatures. Under mesophilic conditions, the effluent and digestate requires further pathogen inactivation.
Level of Development		• Anaerobic digestion technologies are being transferred from wastewater treatment. • There is very limited experience in the design, operation, and maintenance for faecal sludge treatment.

References

Strande, L., Ronteltap, M. & Brdjanovic, D. (2014). *Faecal sludge management: Systems approach for implementation and operation*. London, UK: IWA Publishing. Retrieved from www.sandec.ch/fsm_book

Tilley, E., Ulrich, L., Lüthi, C., Reymond, P. & C. Zurbrügg (2014). *Compendium of sanitation systems and technologies*, 2nd Revised Edition. Dübendorf, Switzerland: Swiss Federal Institute of Aquatic Science and Technology (Eawag). Retrieved from www.sandec.ch/compendium

Black Soldier Fly Larvae



Container used to grow black soldier fly larvae (Credit: CAWST)

Black soldier fly larvae
(Credit: www.michaelcmichaeldo.com)

Pilot scale treatment facility in Indonesia (Credit: Bram Dortmans)

- **Design:** Black soldier fly larvae eat faecal sludge, and in doing so they reduce the volume and stabilize the sludge. Black soldier fly larvae are rich in fat and protein. They are fed to livestock as a source of protein. A black soldier fly does not need to eat once it can fly - in fact it does not have a mouth. Therefore, they are not a vector and do not spread pathogens.
- **Operation:** Black soldier fly larvae treatment is done in batches or semi-continuously. Faecal sludge is placed in a container with black soldier fly eggs or larvae. Other organic waste streams can be added as well to be co-treated. The larvae are harvested periodically to feed to livestock.
- **Time and energy required:** Larvae digest faecal sludge in days. The technology needs low amounts of energy.

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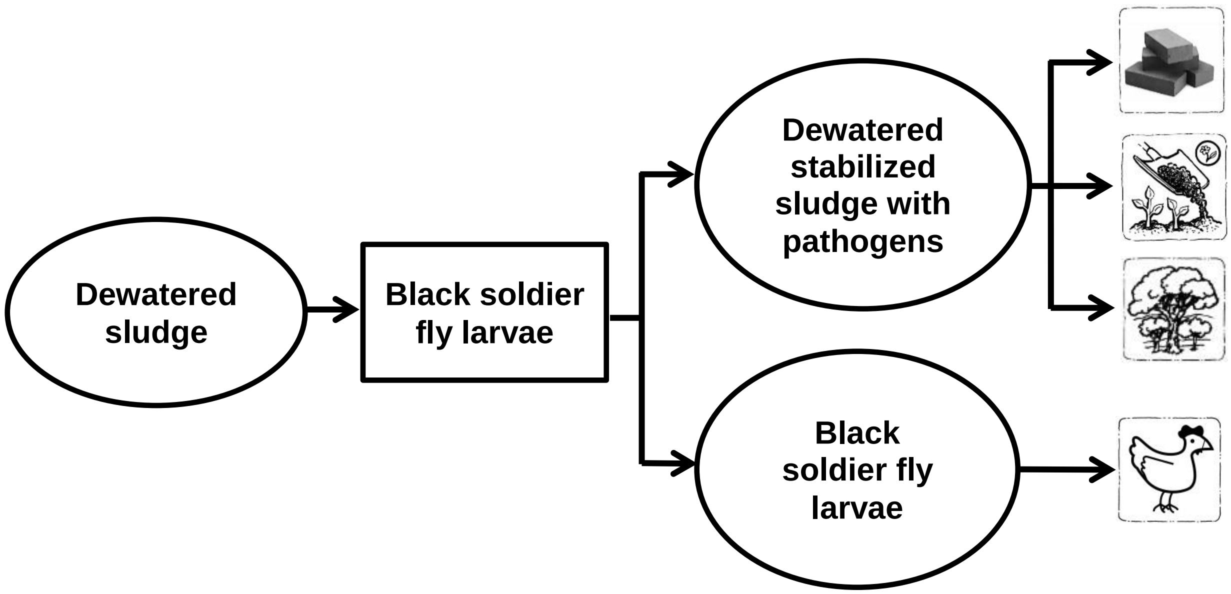
Treatment Technology Description

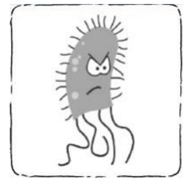


Treatment Objectives	Pathogen Inactivation	**Low**
	Dewatering	
	Stabilization/ Nutrient Management	**Yes**
Pathogen Inactivation		• Some pathogens are inactivated through storage. • Some pathogens are inactivated through other mechanisms, but it is not well understood and more research is needed. • Helminth eggs are not inactivated.
Level of Development		• Black soldier fly larvae treatment for faecal sludge is in the pilot stage. Research is ongoing.

References

Strande, L., Ronteltap, M. & Brdjanovic, D. (2014). *Faecal sludge management: Systems approach for implementation and operation*. London, UK: IWA Publishing. Retrieved from www.sandec.ch/fsm_book

Co-composting



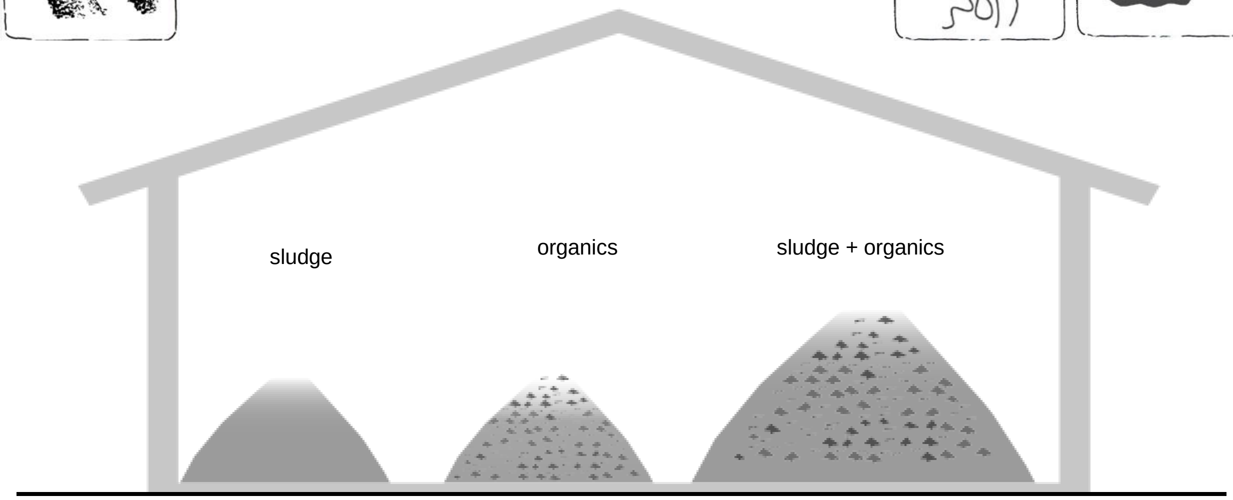
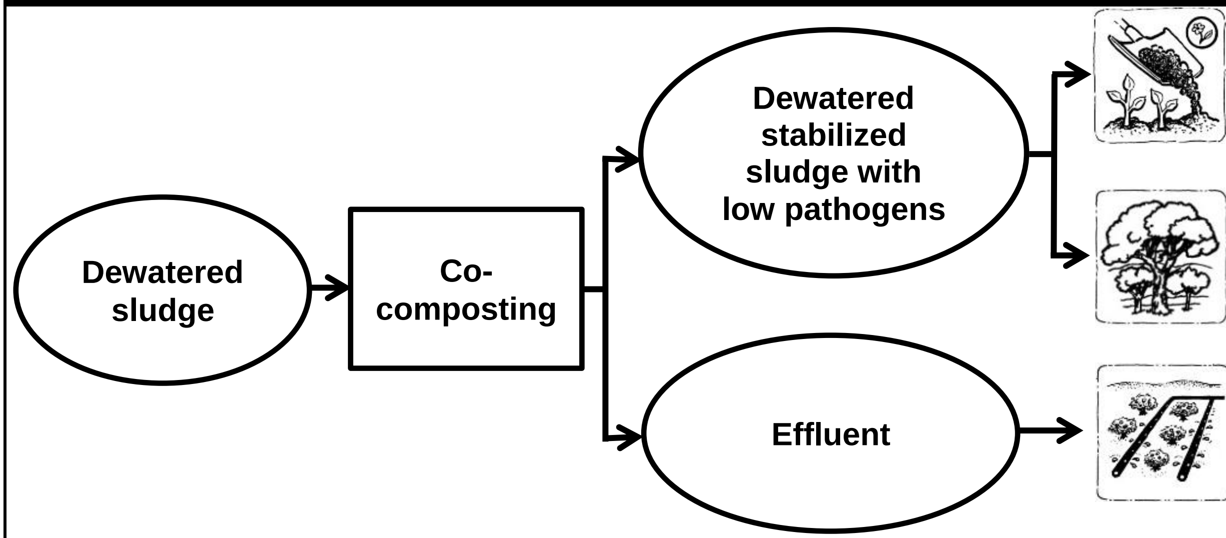


Diagram of co-composting (Credit: Tilley et al., 2014)

Co-composting in Accra, Ghana. (Credit: Eawag-Sandec)

- **Design:** Co-composting stabilizes faecal sludge and inactivates pathogens. Microorganisms break down the organic material in the presence of oxygen. If the process is properly controlled, the temperature of the pile increases resulting in pathogen inactivation, otherwise additional storage or curing is needed to reduce pathogens. The process produces compost, a dark, rich soil-like material, which can be used as a soil conditioner.
- **Operation:** Co-composing is done in batches. Faecal sludge and other organic material (for example, food waste, wood chips) are placed in piles or rows. Various parameters need to be controlled to ensure an optimal composting process, including temperature, moisture, carbon to nitrogen ratio, and oxygen concentration.
- **Time and energy required:** Co-composting takes several months and needs low amounts of energy.

Treatment Technology Description



Treatment Objectives	Pathogen Inactivation	**High**
	Dewatering	**Low**
	Stabilization/ Nutrient Management	**Yes**
Pathogen Inactivation	 	• Pathogens can be inactivated through storage, depending on the retention time. • Pathogens are killed by high temperatures in the compost pile. This heat is produced through the aerobic digestion of organic material. Temperatures should be kept at temperatures above 50°C for at least one week to ensure that pathogens are killed to a safe level (WHO, 2006).
Level of Development		• Co-composting faecal sludge has been widely implemented. There is experience in design, operation, and maintenance.

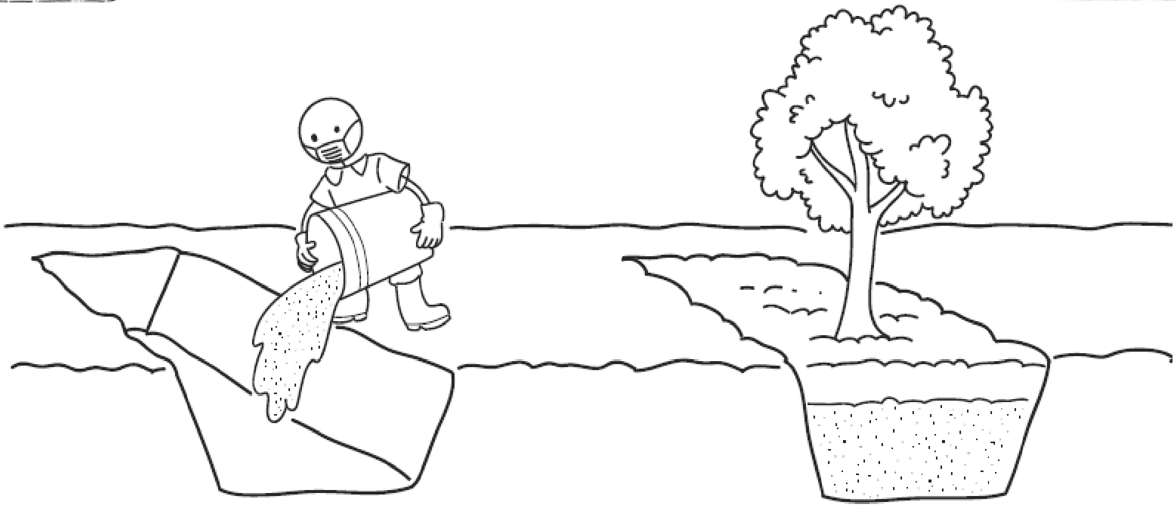
References

Strande, L., Ronteltap, M. & Brdjanovic, D. (2014). *Faecal sludge management: Systems approach for implementation and operation*. London, UK: IWA Publishing. Retrieved from www.sandec.ch/fsm_book

Tilley, E., Ulrich, L., Lüthi, C., Reymond, P. & C. Zurbrügg (2014). *Compendium of sanitation systems and technologies*, 2nd Revised Edition. Dübendorf, Switzerland: Swiss Federal Institute of Aquatic Science and Technology (Eawag). Retrieved from www.sandec.ch/compendium

World Health Organization. (2006). *WHO Guidelines for the safe use of wastewater, excreta and greywater* (Vol. 4). Geneva, Switzerland: WHO. Retrieved from www.who.int/water_sanitation_health/wastewater/gsuww/en/

Deep Row Entrenchment

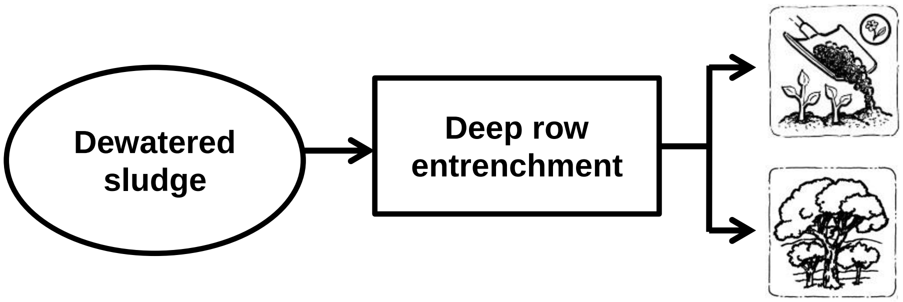


Deep row entrenchment (Credit: CAWST)

Deep row entrenchment of pit latrine faecal sludge in Durban, South Africa
(Credit: Jay Bhagwan, Water Research Council South Africa in Strande et al., 2014)

- **Design:** Deep row entrenchment is a method of disposal and use as a soil amendment. It requires careful design and operation to not contaminate groundwater.
- **Operation:** Deep row entrenchment is done in batches. Untreated faecal sludge is placed in trenches and then covered with soil. Trees are planted on top or next to the trench.

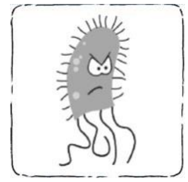
  The length and the depth of the trench depend on the highest groundwater level and the quantity of faecal sludge. The trench can be lined, for example with a layer of clay, to reduce the risk of groundwater contamination.
- **Time and energy required:** Deep row entrenchment needs low amounts of energy.

Treatment Technology Description		
		
Treatment Objectives	Pathogen Inactivation	**Low**
	Dewatering	**Low**
	Stabilization/Nutrient Management	**Yes**
Pathogen Inactivation		• Pathogens are inactivated through storage.
Level of Development		• Has been implemented at full scale for faecal sludge treatment. There is experience in design, operation, and maintenance.

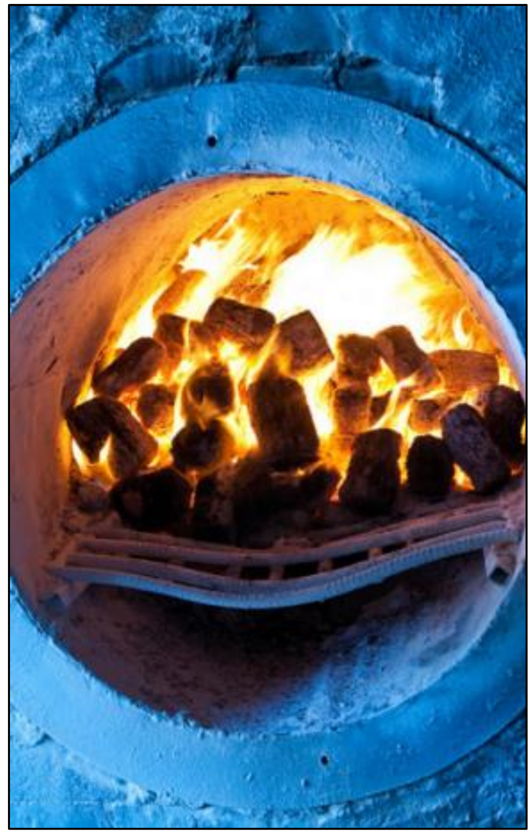
References

Strande, L., Ronteltap, M. & Brdjanovic, D. (2014). *Faecal sludge management: Systems approach for implementation and operation*. London, UK: IWA Publishing. Retrieved from www.sandec.ch/fsm_book

Incineration



Cement industry in Dakar, Senegal (Credit: Eawag-Sandec)



Kiln used for drying clay products in Kampala, Uganda (Credit: Eawag-Sandec)

- **Design:** Incineration means that dry faecal sludge is converted into ash at high temperatures (between 850-900ºC). Incineration reduces the sludge volume and kills all pathogens. The ash can be buried, or used for construction material or as a cover material. Dried faecal sludge can fuel industrial processes, such as cement kilns. Incineration produces air emissions, which needs to be controlled to avoid negative environmental impacts.
- **Operation:** Sludge needs to be dewatered before it is incinerated.
- **Time and energy required:** Incinerating dry faecal sludge takes seconds to minutes. It takes some energy to ignite the sludge, but then it should burn on its own and the net energy is positive.

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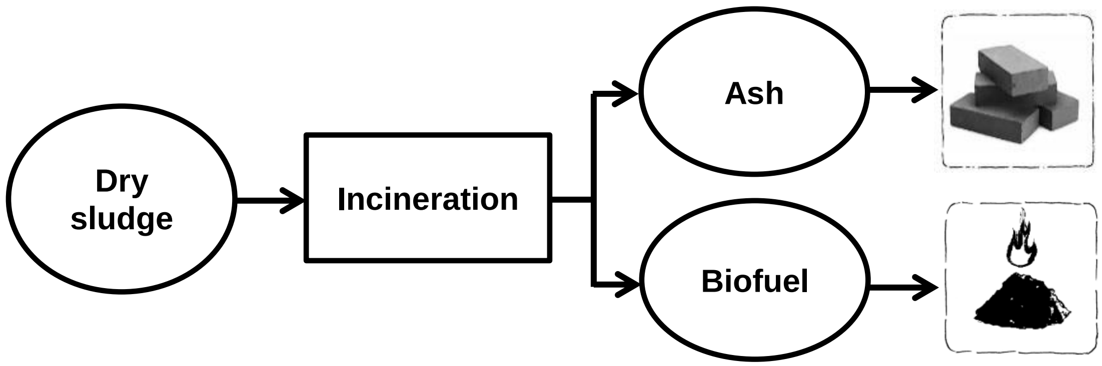
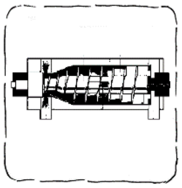
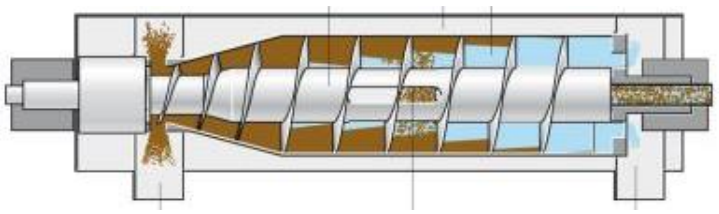
Treatment Technology Description		
		
Treatment Objectives	Pathogen Inactivation	**High**
	Dewatering	**High**
	Stabilization/Nutrient Management	**Yes**
Pathogen Inactivation		• Pathogens are exposed to very high temperatures, which kills everything.
Level of Development		• Sludge incineration is being transferred from wastewater treatment. • There is very limited experience in design, operation, and maintenance for faecal sludge treatment.

References

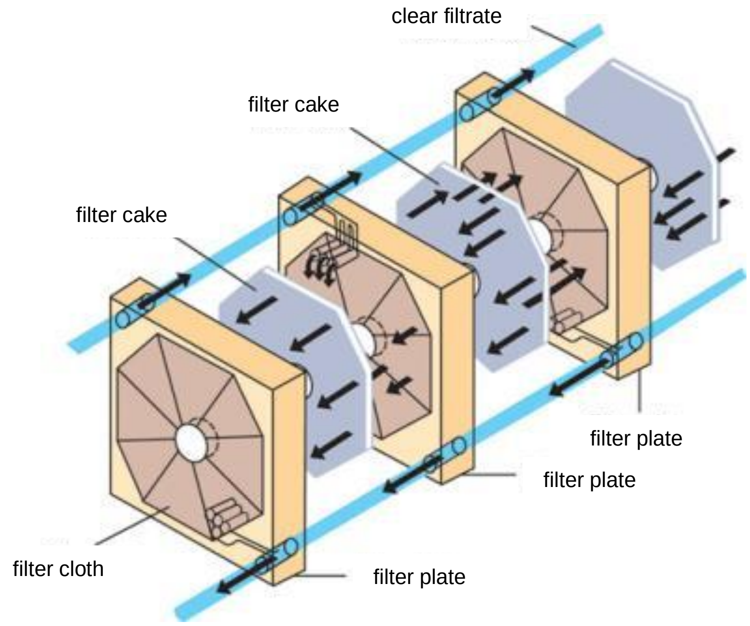
Strande, L., Ronteltap, M. & Brdjanovic, D. (2014). *Faecal sludge management: Systems approach for implementation and operation*. London, UK: IWA Publishing. Retrieved from www.sandec.ch/fsm_book



Mechanical Dewatering



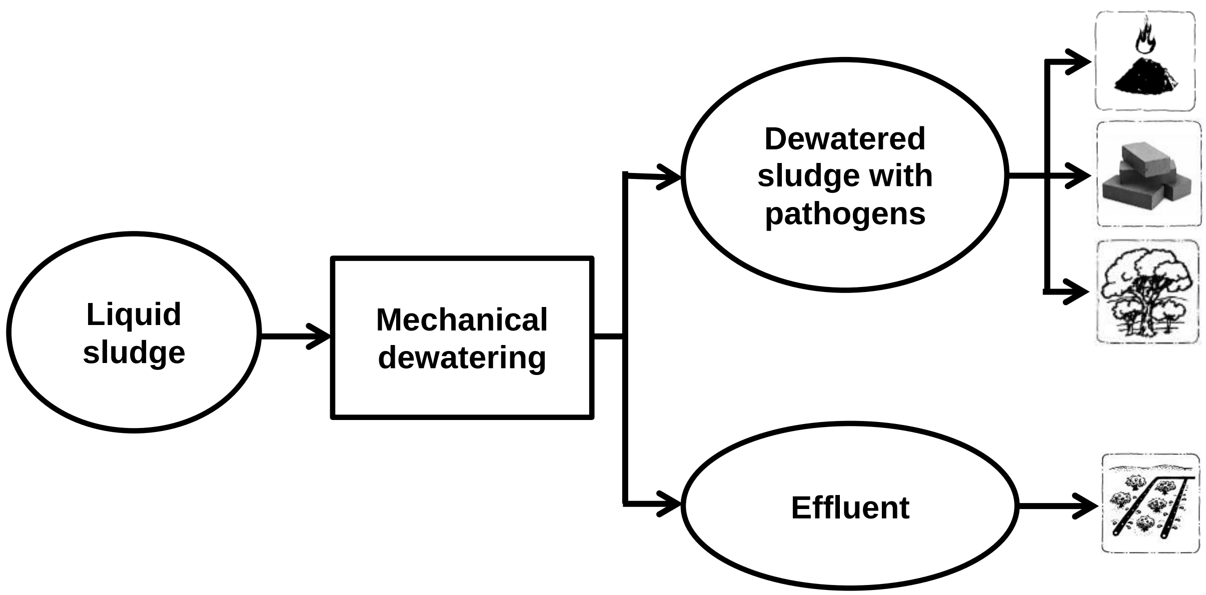
Screw press (Credit: Direct Industry)



Frame filter press (Credit: SuitaFiltech)

- **Design**: Mechanical dewatering technologies include belt filter press, frame filter press, screw press, and centrifuge. Mechanical forces dewater faecal sludge (for example, centrifugal force).
- **Operation**: Conditioners often need to be added to the faecal sludge before mechanical dewatering. Conditioners are products that help to dewater the sludge more efficiently.
- **Time and energy required**: Mechanical dewatering is fast (takes minutes to hours) and it needs less space, but it uses large amounts of energy.

Treatment Technology Description



Treatment Objectives	Pathogen Inactivation	**Low**
	Dewatering	**High**
	Stabilization/Nutrient Management	**No**
Pathogen Inactivation		• No information is available about pathogen inactivation for mechanical dewatering.
Level of Development		• Mechanical dewatering technologies are being transferred from wastewater treatment. • There is limited experience in design, operation, and maintenance specifically for faecal sludge treatment.

References

Strande, L., Ronteltap, M. & Brdjanovic, D. (2014). *Faecal sludge management: Systems approach for implementation and operation*. London, UK: IWA Publishing. Retrieved from: www.sandec.ch/fsm_book

Planted Drying Bed

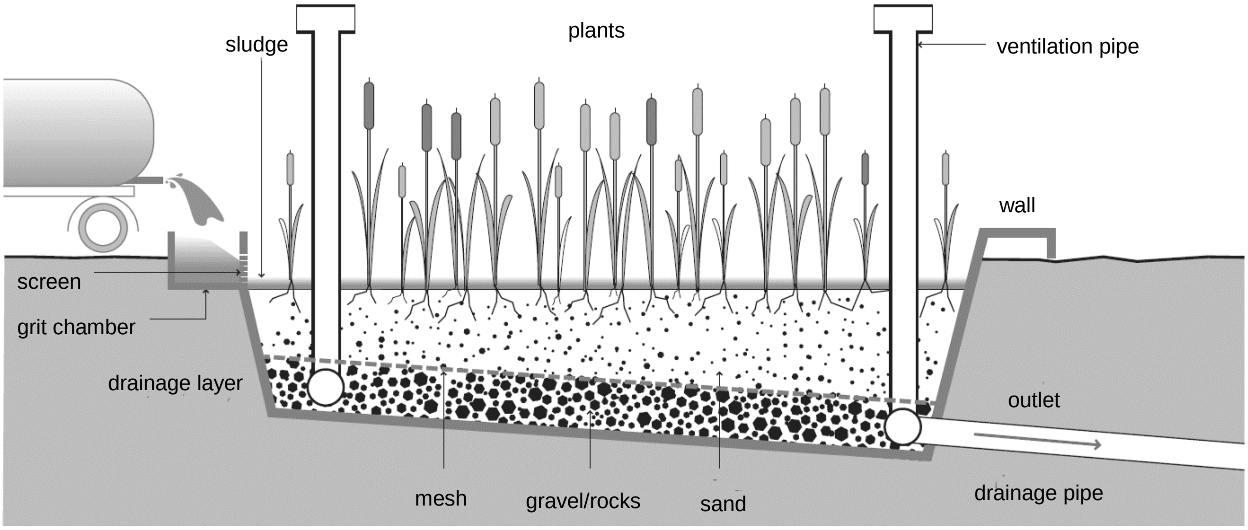
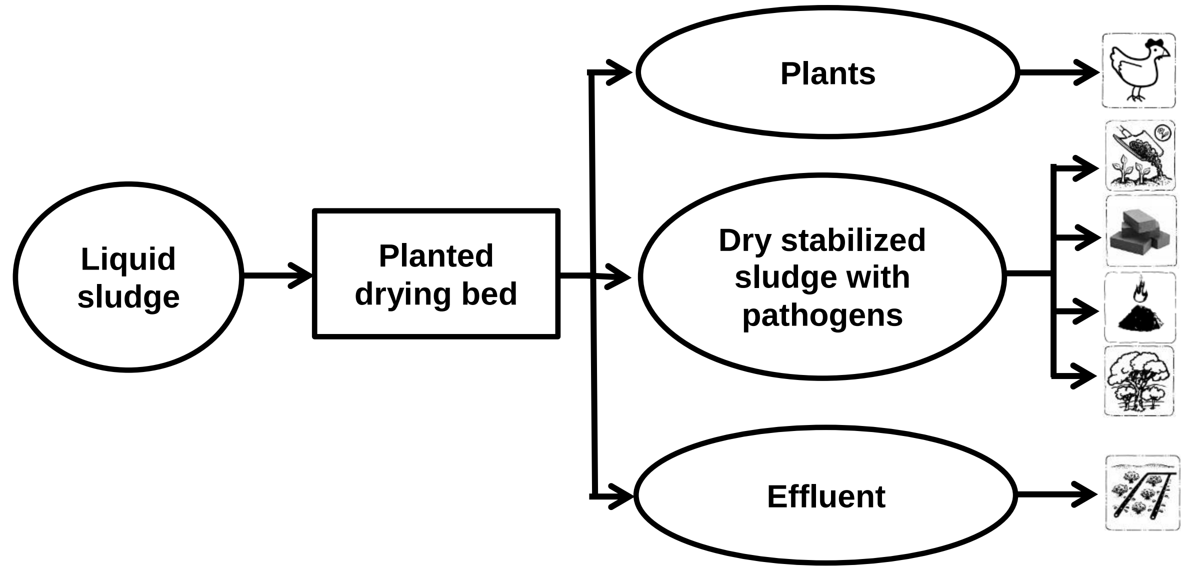


Diagram of a planted drying bed (Credit: Tilley et al., 2014)


Planted drying bed in Bangladesh (Credit: FSM Action Research Blog)

- **Design:** A planted drying bed is filled with filter material, usually gravel at the bottom and sand on top. Plants selected for a specific climate grow in the filter media. The bottom of the bed is sloped and lined with perforated pipes to drain away the liquid (called effluent).
- **Operation:** Planted drying beds operate (semi-)continuously. Faecal sludge is placed on the surface of the bed and the liquid flows through the sand and gravel. The majority of the solid portion of the sludge stays on the surface. Some of the remaining water in the sludge is removed by evapotranspiration. Sludge can be loaded on the beds without removal for a period of years. Depending on the retention time, the dewatered sludge is stabilized.
- **Time and energy required:** The plants are harvested depending on their growth cycle. Dewatered sludge is removed every few months to years. Planted drying beds require low amounts of energy.

Treatment Technology Description



Treatment Objectives	Pathogen Inactivation	**Medium**
	Dewatering	**Medium**
	Stabilization/Nutrient Management	**Yes**
Pathogen Inactivation		• Some pathogens are inactivated through drying and storage depending on the retention time. • At the surface of the sludge, some pathogens are inactivated by sunlight. • The majority of helminth eggs are retained on the surface of the drying bed. • More bacteria, viruses, and protozoa leave the bed with the effluent.
Level of Development		• Has been implemented in multiple countries for faecal sludge treatment. There is experience in design, operation, and maintenance.

References

Strande, L., Ronteltap, M. & Brdjanovic, D. (2014). *Faecal sludge management: Systems approach for implementation and operation*. London, UK: IWA Publishing. Retrieved from: www.sandec.ch/fsm_book

Tilley, E., Ulrich, L., Lüthi, C., Reymond, P. & C. Zurbrügg (2014). *Compendium of sanitation systems and technologies*, 2nd Revised Edition. Dübendorf, Switzerland: Swiss Federal Institute of Aquatic Science and Technology (Eawag). Retrieved from: www.sandec.ch/compendium

Settling-Thickening

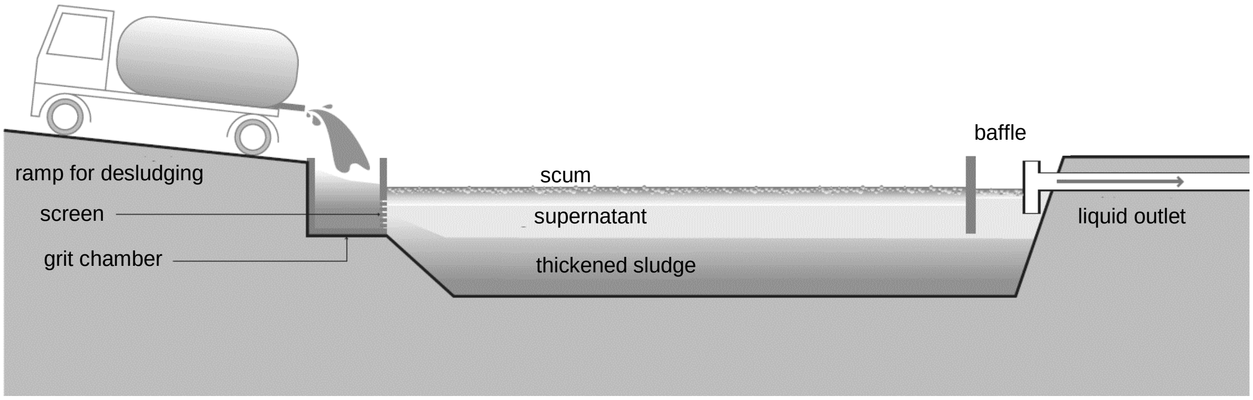
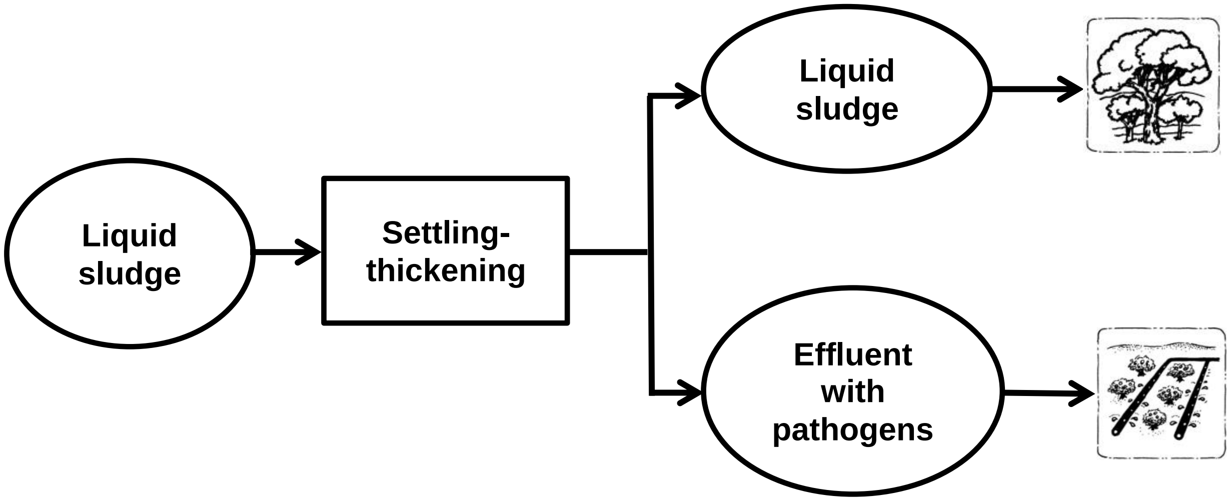


Diagram of a settling-thickening tank (Credit: Tilley et al., 2014)

Two settling-thickening tanks in Kampala, Uganda (Credit: Lars Schoebitz)

- **Design:** Settling-thickening technologies thicken and dewater faecal sludge. Solids settle to the bottom as the faecal sludge flows from one end of the pond or tank to the other. The liquid (effluent) flows through the outlet and requires further treatment. Some solids (for example, fats, oils, and grease) float to the top and form a scum layer. Example technologies include settling-thickening tanks, settlers, Imhoff tanks, and septic tanks.
- **Operation:** Settling-thickening technologies operate (semi-)continuously. Settling-thickening technologies often include two lined ponds or tanks. While one is being operated, sludge thickens in the second. The sludge is then pumped out for further treatment.
- **Time and energy required:** Sludge is removed every month to every few months. Other than pumping, settling-thickening technologies require low amounts of energy.

Treatment Technology Description



Treatment Objectives	Pathogen Inactivation	**Low**
	Dewatering	**High**
	Stabilization/Nutrient Management	**No**
Pathogen Inactivation		• The objective is to dewater and increase the concentration of solids in faecal sludge, not to reduce pathogens. • Some pathogens may be killed through storage, depending on the retention time. • The effluent requires further treatment before use for irrigation in agriculture.
Level of Development		• Has been implemented in many countries for faecal sludge treatment. There is experience in design, operation, and maintenance.

References

Strande, L., Ronteltap, M. & Brdjanovic, D. (2014). *Faecal sludge management: Systems approach for implementation and operation*. London, UK: IWA Publishing. Retrieved from: www.sandec.ch/fsm_book

Tilley, E., Ulrich, L., Lüthi, C., Reymond, P. & C. Zurbrügg (2014). *Compendium of sanitation systems and technologies*, 2nd Revised Edition. Dübendorf, Switzerland: Swiss Federal Institute of Aquatic Science and Technology (Eawag). Retrieved from: www.sandec.ch/compendium

Thermal Drying

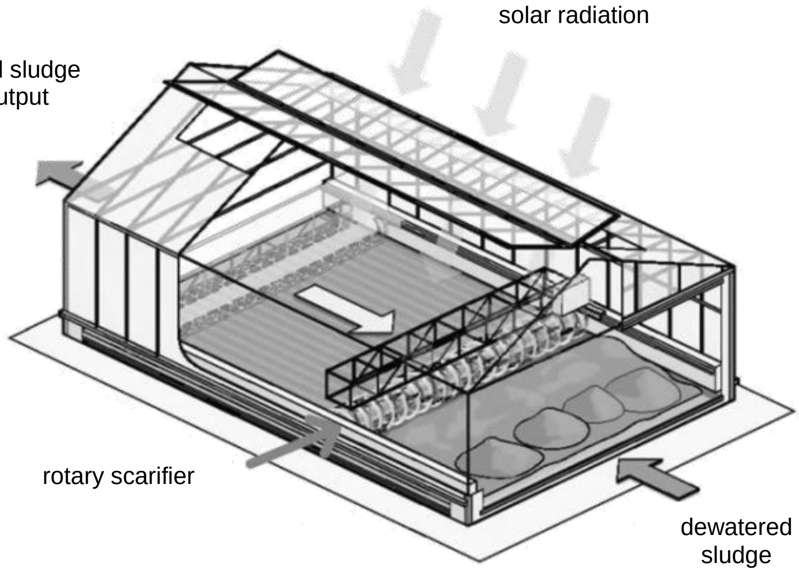


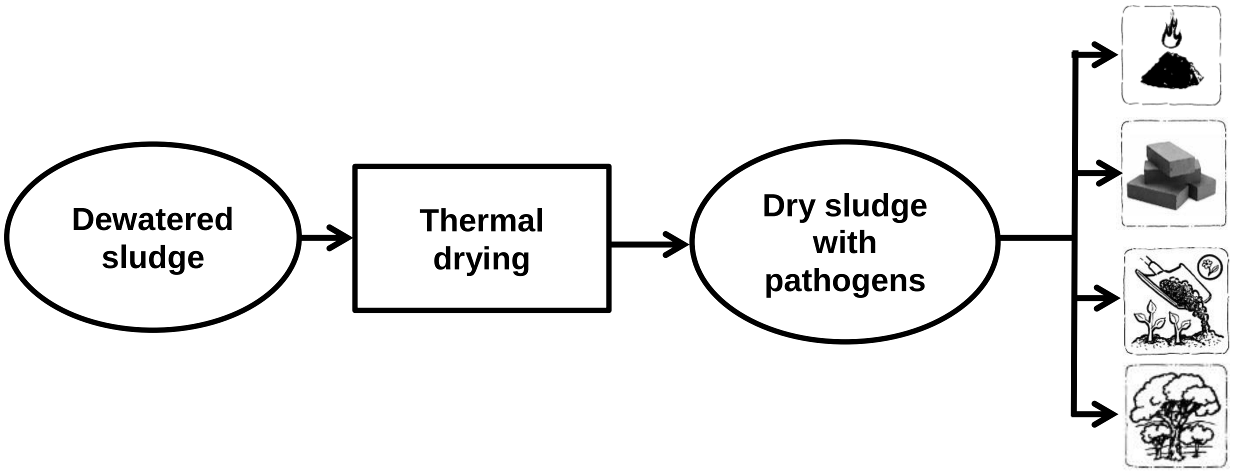
Diagram of a solar drying technology (Adapted: Suez Environment)

A thermal dryer used for drying wastewater sludge before combustion in Switzerland (Credit: Eawag-Sandec)

- **Design:** Thermal drying technologies remove more moisture from dewatered faecal sludge.
- **Operation:** Thermal drying technologies operate in batches, continuously or (semi-)continuously. Energy for drying can be solar or through other forms of energy, for example waste heat from industries.

  Solar drying usually takes place in a greenhouse with transparent covers. Sludge is spread on the floor in shallow basins. The temperature in the greenhouse increases with sunlight and the water in the sludge evaporates. The greenhouse needs to have good ventilation to remove the moist air.
- **Time and energy required:** Thermal drying takes hours to weeks. They require a lot of energy, which can be provided through solar and waste heat.

Treatment Technology Description



Treatment Objectives	Pathogens	**Medium**
	Dewatering	**Medium**
	Stabilization/Nutrient Management	**No**
Pathogen Inactivation		• Some pathogens are inactivated through drying and storage, depending on the retention time. • Some pathogens at the surface of the sludge layer are inactivated by sunlight.
Level of Development		• Thermal drying technologies are being transferred from wastewater treatment. • There is limited experience in design, operation, and maintenance specifically for faecal sludge treatment.

References

Strande, L., Ronteltap, M. & Brdjanovic, D. (2014). *Faecal sludge management: Systems approach for implementation and operation*. London, UK: IWA Publishing. Retrieved from: www.sandec.ch/fsm_book

Unplanted Drying Bed

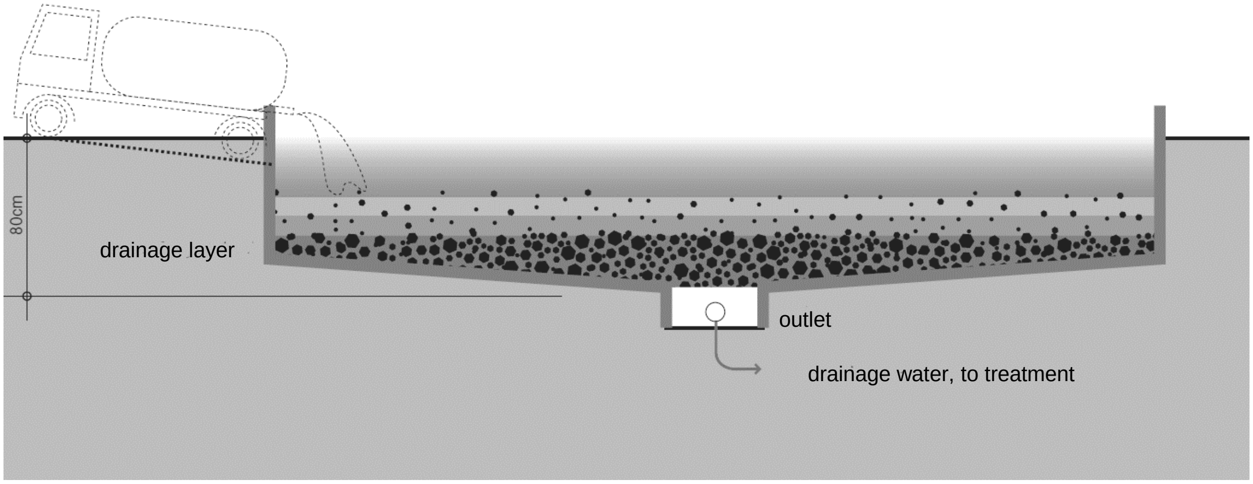
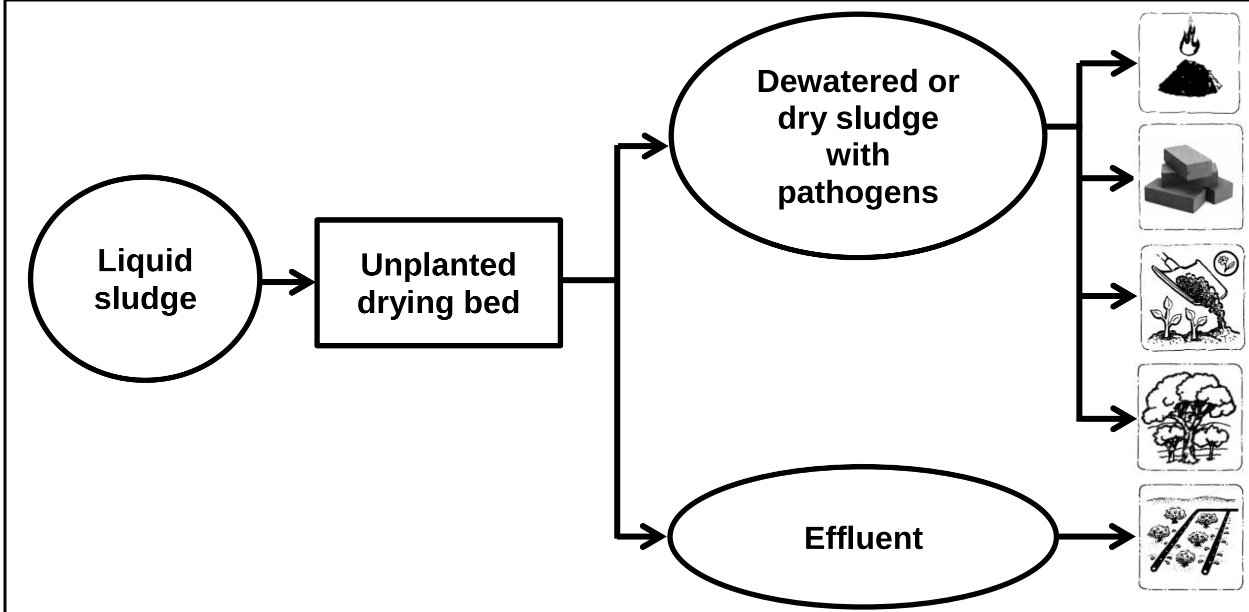


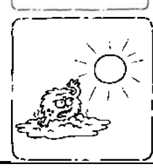
Diagram of an unplanted drying bed (Credit: Tilley et al., 2014)

Unplanted drying beds at a faecal sludge treatment facility in Dakar, Senegal (Credit: Eawag-Sandec)

- **Design:** Unplanted drying beds dewater faecal sludge. An unplanted drying bed is filled with filter material, usually gravel at the bottom and sand on top. The bottom of the bed is sloped and lined with perforated pipes to drain away the liquid (called effluent).
- **Operation:** Unplanted drying beds are operated in batches. Sludge is placed on the surface of the bed and the liquid flows through the sand and gravel for a period of days. The majority of the solid portion of the sludge stays on the surface. Some of the remaining water in the sludge is removed by evaporation. The dewatered sludge is then removed from the surface manually or mechanically.
- **Time and energy required:** Dewatered or dried sludge is removed every few weeks to months. Unplanted drying beds require low amounts of energy.

Treatment Technology Description



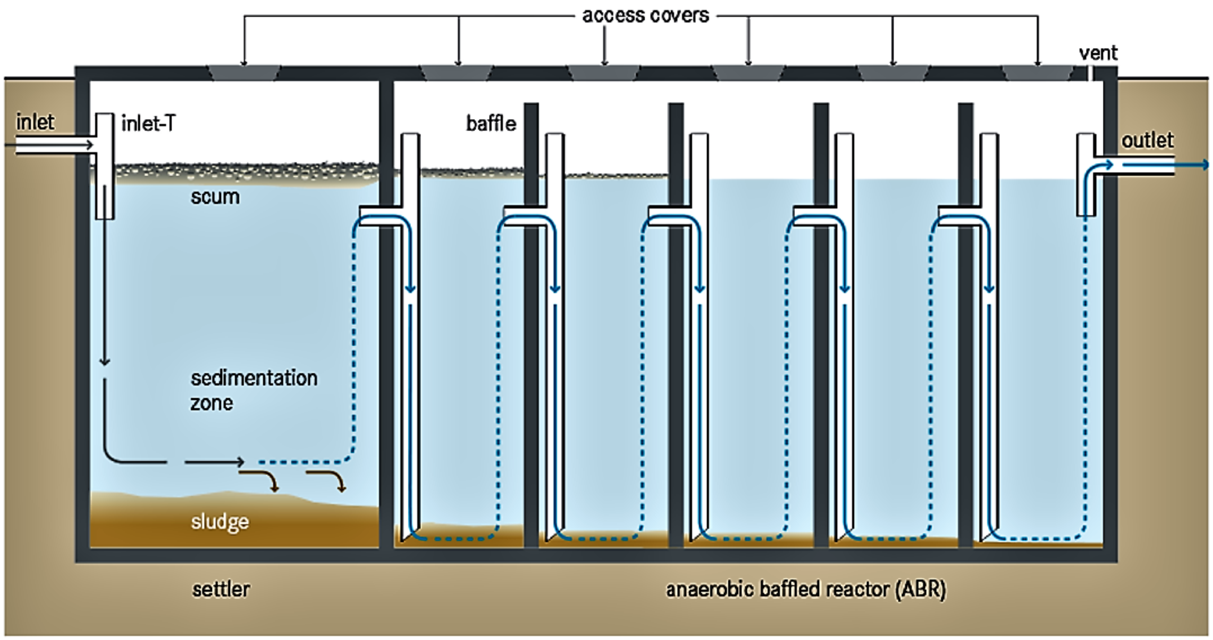
Treatment Objectives	Pathogen Inactivation	**Medium**
	Dewatering	**High**
	Stabilization/Nutrient Management	**No**
Pathogen Inactivation	  	• Some pathogens are inactivated through drying and storage depending on the retention time. • At the surface, some pathogens are inactivated by sunlight. • More helminth eggs are retained on the surface of the drying bed than in the effluent. • Some of the bacteria, viruses, and protozoa leave with the effluent.
Level of Development		• Many countries have implemented drying beds for faecal sludge treatment. There is some experience in design, operation, and maintenance.

References

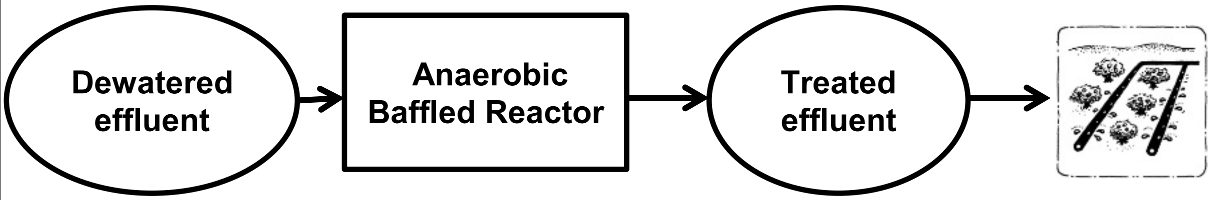
Strande, L., Ronteltap, M. & Brdjanovic, D. (2014). *Faecal sludge management: Systems approach for implementation and operation*. London, UK: IWA Publishing. Retrieved from: www.sandec.ch/fsm_book

Tilley, E., Ulrich, L., Lüthi, C., Reymond, P. & C. Zurbrügg (2014). *Compendium of sanitation systems and technologies*, 2nd Revised Edition. Dübendorf, Switzerland: Swiss Federal Institute of Aquatic Science and Technology (Eawag). Retrieved from: www.sandec.ch/compendium

Anaerobic Baffled Reactor



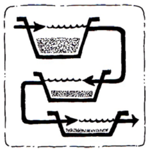
- The majority of settleable solids are removed in a sedimentation chamber in front of the actual ABR. Small-scale stand-alone units typically have an integrated settling compartment, but primary sedimentation can also take place in a separate settler or another preceding technology (e.g., existing septic tanks). Critical design parameters include a hydraulic retention time (HRT) between 48 to 72 hours, upflow velocity of the wastewater below 0.6 m/h and the number of upflow chambers (3 to 6).
- Accessibility to all chambers (through access ports) is necessary for maintenance. Usually, the biogas produced in an ABR through anaerobic digestion is not collected because of its insufficient amount.
- An ABR requires a start-up period of several months to reach full treatment capacity since the slow growing anaerobic biomass first needs to be established in the reactor. To reduce start-up time, the ABR can be inoculated with anaerobic bacteria, e.g., by adding fresh cow dung or septic tank sludge.

Treatment Technology Description		
		
Treatment Objectives	Pathogen Inactivation	No
	Dewatering	Settling of suspended solids is happening in the first compartment(s)
	Stabilization/Nutrient Management	Yes
Level of Development		• ABRs have been widely implemented. There is experience in design, operation, and maintenance.

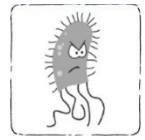
+ Resistant to organic and hydraulic shock loads	- Low reduction of pathogens and nutrients
+ High reduction of BOD	- Requires expert design and construction
+ Low sludge production; the sludge is stabilized	- Effluent and sludge require further treatment and/or appropriate discharge
+ Low operating costs	
+ No electrical energy is required	
+ Moderate area requirement (can be built underground)	
+ Long service life	

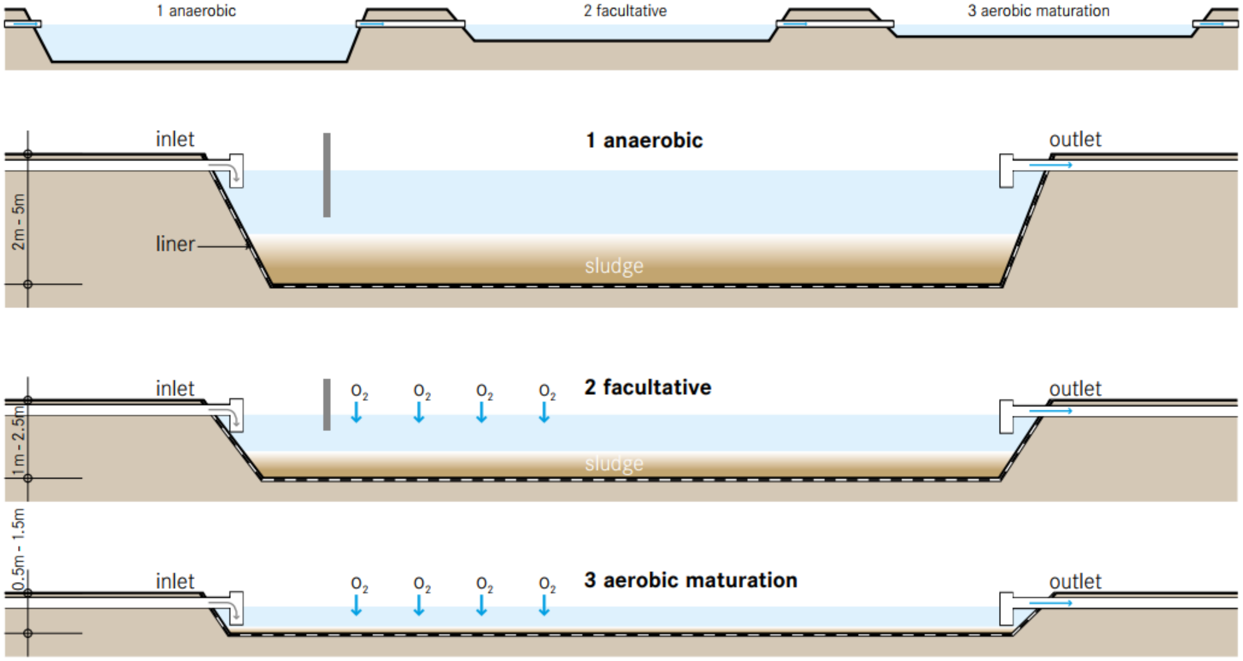
References

Tilley, E., Ulrich, L., Lüthi, C., Reymond, P. & C. Zurbrügg (2014). *Compendium of sanitation systems and technologies*, 2nd Revised Edition. Dübendorf, Switzerland: Swiss Federal Institute of Aquatic Science and Technology (Eawag). Retrieved from www.sandec.ch/compendium



Waste stabilization ponds

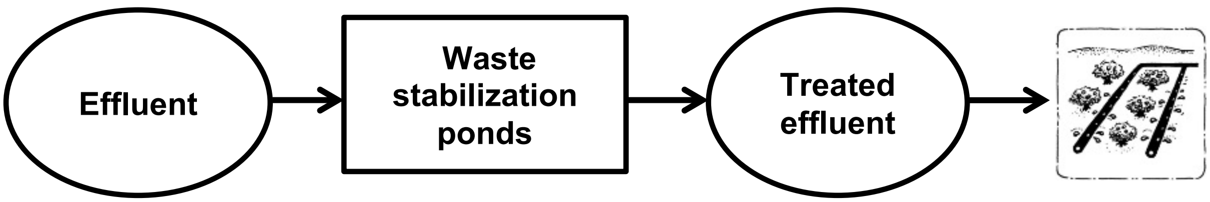


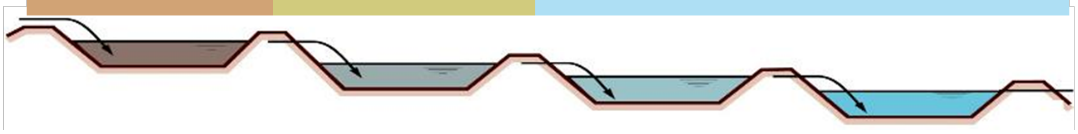
Waste stabilization ponds are a common effluent treatment technology for faecal sludge, here from settling-thickening tanks and drying beds in Kampala, Uganda. (Credit: Eawag-Sandec)

- Pre-treatment is essential to prevent scum formation and to hinder excess solids and garbage from entering the ponds.
- Aerobic ponds: The main function of anaerobic ponds is BOD removal. The process (as in septic tanks) relies on the sedimentation of settable solids and subsequent anaerobic digestion in the

resulting sludge layer. During anaerobic digestion, biogas is produced which could be collected by covering the anaerobic pond with a floating plastic membrane.

- Facultative ponds: consist of an aerobic zone close to the surface and a deeper, anaerobic zone. They are designed for BOD removal. The algal production of oxygen occurs near the surface of aerobic ponds to the depth to which light can penetrate (i.e. typically up to 500 mm). Additional oxygen can be introduced by wind due to vertical mixing of the water.
- Maturation ponds: Maturation or polishing ponds are essentially designed for pathogen removal and retaining suspended stabilized solids. The size and number of maturation ponds depends on the required bacteriological quality of the final effluent. The principal mechanisms for faecal bacterial removal in facultative and maturation ponds are HRT, temperature, high pH (> 9), and high light intensity.

Treatment Technology Description		
		
Treatment Objectives	Pathogen Inactivation	Partially
	Dewatering	No
	Stabilization/Nutrient Management	Yes
Pathogen Inactivation		• Maturation ponds are an example of an effluent treatment technology (also called polishing ponds). In these shallow ponds, pathogens are inactivated by solar radiation.
Level of Development		• WSPs have been widely implemented. There is experience in design, operation, and maintenance.

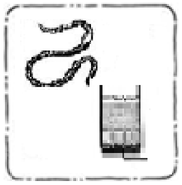


	Anaerobic Pond	Facultative Pond	Maturation Ponds
Design	Deep (2-5m) and highly loaded but rather small area	Shallow (<1.5m) but large → Oxygen supply (algae, wind, artificial aeration)	Shallow (<1m) but large area
Flow	Hydraulic retention time: 1 to 3 days	Hydraulic retention time: 10 to 20 days	Hydraulic retention time: 10 days
Function	Sedimentation and anaerobic stabilisation of sludge (BOD reduction 40-50%) → **settling**	Aerobic degradation of suspended and dissolved matter (BOD reduction 50-70%) → **degradation**	Final sedimentation of suspended solids, bacteria mass and pathogens → **hygienisation**

+ Resistant to organic and hydraulic shock loads	- Requires a large land area
+ High reduction of solids, BOD and pathogens	- High capital costs depending on the price of land
+ High nutrient removal if combined with aquaculture	- Requires expert design and construction
+ Low operating costs	- Sludge requires proper removal and treatment
+ No electrical energy is required	
+ No real problems with insects or odours if designed and maintained correctly	

References

Tilley, E., Ulrich, L., Lüthi, C., Reymond, P. & C. Zurbrügg (2014). *Compendium of sanitation systems and technologies*, 2nd Revised Edition. Dübendorf, Switzerland: Swiss Federal Institute of Aquatic Science and Technology (Eawag). Retrieved from www.sandec.ch/compendium



Vermifilter

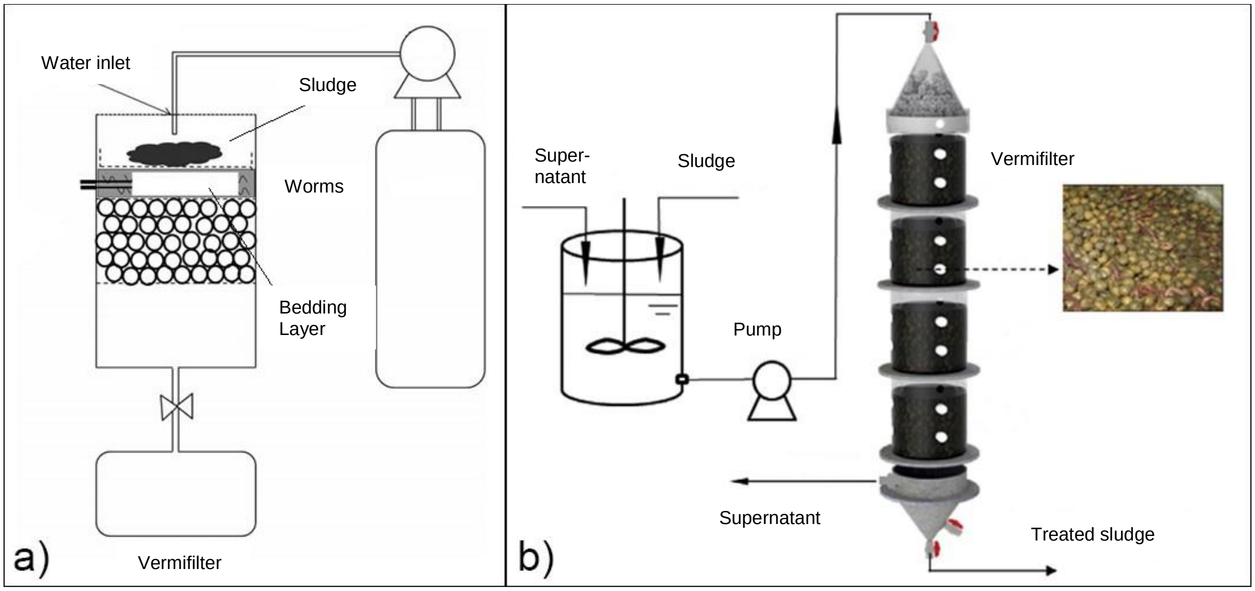


Diagram of different types of vermifilters
a) Diagram of a rectangular vermifilter with bedding and drainage layers [Credit: Furlong, Templeton & Gibson (2014, p. 233)]
b) Diagram of a cylindrical vermifilter with all compartments filled with a bedding layer [Credit: Xing et al. (2016b, 1089)]

Vermifiltration bins in a pilot project in India (Credit: IFRC)

- **Design:** Vermifilters are filters which contain composting worms. The feacal sludge is added directly to the filters where the composting worms and environment stabilizes the feacal sludge through vermicomposting. Vermicomposting stabilizes dewatered faecal sludge. Composting worms break down the organic material as it passes through them. Vermifilters require a layer of bedding material (where the worms live) and a filtration layer. The bedding material must be made of organic material, such as woodchips. The filtration layer may be made from a variety of materials, such as gravel.
- **Operation:** Vermifiltration is done semi-continuously.
- **Time and energy required:** Worms digest faecal sludge in days. The technology needs low amounts of energy.

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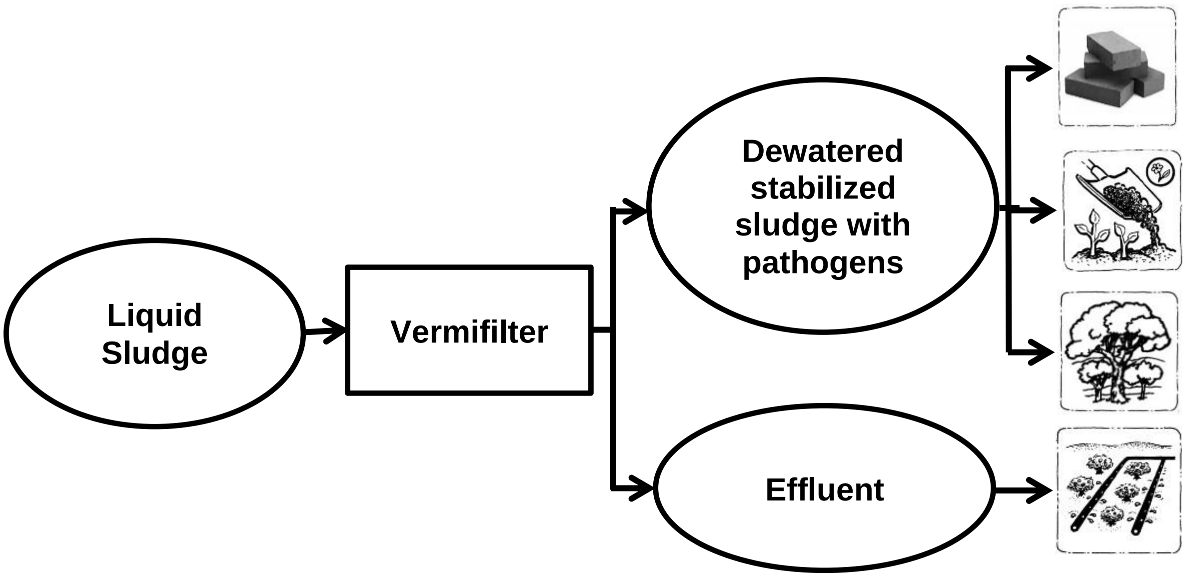
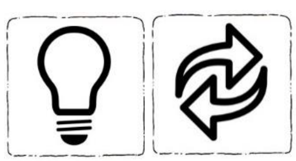
Treatment Technology Description



Treatment Objectives	Pathogen Inactivation	**Low**
	Dewatering	**Yes**
	Stabilization/Nutrient Management	**Yes**
Pathogen Inactivation		• Some pathogens are inactivated through the action of the worms and storage. • More research is needed to understand the other pathogen inactivation mechanisms.
Level of Development		• Vermifiltration is being transferred from wastewater treatment. • Vermifiltration for faecal sludge treatment is in the pilot stage. Research is ongoing. • There is very limited experience in design, operation, and maintenance specifically for faecal sludge treatment.

References

Strande, L., Ronteltap, M. & Brdjanovic, D. (2014). *Faecal sludge management: Systems approach for implementation and operation*. London, UK: IWA Publishing. Retrieved from www.sandec.ch/fsm_book

C. Furlong (Personal communication, August 23, 2016)