EVALUATION OF A MECHANICAL SOLID-LIQUID SEPARATOR FOR SWINE MANURE

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1. EXECUTIVE SUMMARY

A mechanical solid-liquid separator was tested on a commercial swine operation. The TR separator was tested on six occasions during the summer and fall of 2000 and 2001. The TR separator was designed for use on swine and dairy farms in Asia and has been distributed by Blossum Agritec in North America since 1998, The system uses a combination of physical processes, including screens and a corkscrew press, to achieve solid-liquid separation.

The separator was capable of processing up to 15 m^3/hr of liquid swine manure containing initial solids concentrations ranging from 3.4 to 8.1%. The efficiency of the system, in terms of the mass removal of manure solids, typically exceeded 20% and ranged from 13 to 47%. Average mass removal efficiencies for phosphorus, nitrogen, and potassium were 28%, 18%, and 12%, respectively. With respect to the mass removal of solids and nutrients the TR separator appeared to perform as well as, if not better, than other swine manure mechanical separators which have been independently tested.

Pollutant concentration reductions in the liquid fraction were lower than those typically achieved through the use of conventional lagoon systems. The separated liquid fraction of the manure consistently possessed BOD_5 concentrations of at least 5000 mg/l and total nitrogen concentrations exceeding 2000 mg/l. The dry matter content of the separated solids was usually less than 20%. The solids, which represented approximately 15% of the original volume of raw manure, did not pile easily and produced significant leachate. The C:N ratio of the solid material ranged from 9.5 to 19.

The TR separator requires an initial capital investment of \$30,000 to \$50,000. The economic benefit of using a mechanical solid-liquid separator to process swine manure will largely depend on the potential for solids reuse and value recovery. If the liquid fraction is to be irrigated onto cropland a mechanical separator can eliminate the need for land-intensive lagoon systems to remove large solids. The effluent would require additional advanced treatment before it could be discharged to the natural environment.

1. INTRODUCTION

In recent years, considerable public attention has been directed towards the production and management of manure within the swine industry. The proliferation of liquid waste handling systems for hog production, and the increased size of individual livestock operations, are often quoted as the root causes of environmental problems associated with hog farming. Liquid waste handling systems are popular for livestock production because of their ease of mechanization and low labour requirements (Zhang and Westerman, 1997).

Many farms have expanded their animal production without possessing the land base necessary to dispose of the increased wasteload in an environmentally sustainable manner. Liquid manure systems exacerbate the problem as a larger volume of diluted waste is typically produced. The cost of transporting this material to arable land that possess nutrient deficits can be high (Moller et al, 2000), thus it is usually stored and partially treated in large earthen lagoons. The storage of high strength waste slurries in large anaerobic lagoons contributes to several environmental problems including pollution of groundwater, discharge of only partially treated effluent to surface water systems, odour generation, ammonia volatilization and greenhouse gas emissions (Zhang and Westerman, 1997; Pieters et al. 1999).

In addition to preventing environmental contamination and nuisance complaints, hog farmers are also concerned with recovering valuable nutrients contained within liquid waste products. As liquid swine waste consists mainly of water, it would be desirable to concentrate the nutrients into a smaller volume before being transported for land application (Pieters et al. 1999). Several technologies exist for separating solid and liquid fractions of dilute waste streams. A host of mechanical and chemical separation methods have been developed for the treatment of municipal and industrial effluents, however very few have been applied in swine systems (Chastain et al. 1998). Gravity separation techniques have traditionally been employed within the agricultural sector.

The advantages of solid-liquid separation within the swine industry include odour reduction, concentrating nutrients into an easily managed form, less loading on lagoons or other treatment systems, and the possible production of a valuable material (Zhang and Westerman, 1997). Generally, it is the cost which has precluded the use of more advanced separation technology within the swine industry in North America. The application of conventional wastewater treatment technologies within agriculture has been more forthcoming in Asia and Europe because of shrinking or inadequate land resources. A similar trend in becoming evident in North America, as the nature of food production continues to intensify and society further scrutinizes agricultural activities.

2. BACKGROUND

2.1. Swine Slurry characteristics

Several mechanical solid-liquid separation systems have been developed specifically for the agricultural industry. The basic principles of their development have been borrowed primarily from municipal wastewater treatment systems. Before applying a separation technology it first important to understand the physical and chemical characteristics of the material which is to be treated. Important waste characteristics that must be considered are: (i) particle size distribution and (ii) the distribution of nutrients and organic matter within each particle size class. The total solids (TS) content of a wastewater is made up of total suspended solids (TSS), and total dissolved solids (TDS). In swine manure, 45 to 65% of the TS is comprised of TSS, as compared to dairy or beef manure where as much as 80% of the TS are made up of TSS (Zhang and Westerman, 1997). The TSS fraction is the solids component which mechanical separators are designed to remove.

Hill and Toller (1980) found that most of the reduced compounds in swine manure (those that would contribute most to odour generation) are contained within the finest fraction of manure solids (<0.105 mm). They also found that a substantial portion of the nutrients and organic matter were also contained within this fine fraction (46% of TS, 70% of total kjedhal nitrogen (TKN), 47% of chemical oxygen demand (COD), and 75% of total phosphorus (TP)). Phosphorus should be the nutrient that is most readily removed by solid-liquid separation as it relatively insoluble and assumed to be mainly associated with the solid fraction. The primary nitrogen (N) form within swine manure is ammonia-N (NH_3-N) (Moller et al. 2000). Both NH_3-N and potassium (K) are soluble and usually associated with the dissolved fraction (Bicudo, 2001). Physical separation processes will transfer little N and K to the solid fraction (Moller et al. 2000).

If a separation technology is to be effective within the swine industry it must be capable of removing particles < 0.25 mm is size in order to reduce odours and retain nutrients within the solids fraction (Hill and Toller, 1980; Bicudo, 2001). Some researchers have put even more stringent requirements on swine waste separators, stating the particles < 0.075 mm must be removed from the waste stream before any effect on odour production is achieved (Ndegwa et al. 2000). Fine fractions of waste are more readily decomposed than larger fractions, and typically contribute more to odour generation (Zhang and Westerman, 1997). As well as removing a substaintial mass of nutrients and solids from the liquid stream, a separation system must be capable of producing a relatively dry solid fraction (<80% moisture content) that can be stored and moved easily. Very few separators, that have been tested with swine waste, are capable of producing a solid fraction that can be piled easily (Chastain et al. 1998).

2.2. Mechanical Solid-Liquid Separation Technology

The four physical separation processes that have been included in agricultural waste separation equipment are sedimentation, screening, centrifugation and filtration. Sedimentation (gravity process) and screening (mechanical process) being the most common (Zhang and Westerman, 1997). Mechanical separation devices are typically categorized based on these basic principles.

Screen Separators (Stationary, Vibrating, and Rotating)
Stationary screens are typically mounted on an incline. The raw liquid slurry is pumped to the top edge of the screen and allowed to flow over the screen. Liquids pass through the screen while solids move down the face of the screen and accumulate at the bottom. The system has no moving parts, no power requirements (except for the pump), but is susceptible to clogging and therefore requires diligent maintenance (Fernandes, 1988). A vibrating screen consists of a flat circular screen that vibrates. Liquid sluice through the screen while solids that remain on the screen are slowly vibrated to the edges of the screen where they are collected. This system is semi self-cleaning but requires power. A rotating screen consists of a horizontal rotating perforated drum. Slurry is applied at the top of unit as the drum is spinning. Liquids pass through the holes in the drum while retained solids are scrapped into a collection area. This design is the most efficient with respect to keeping the screen holes open (Zhang and Westerman, 1997). Screens typically only achieve solids fractions with moisture contents between 85 to 95% (Zhang and Westerman, 1997).

Centrifuges
These devices typically consist of a horizontal or vertical cylinder which is continously turned at high velocities. Centrifugal forces separate the liquids and solids onto the inside wall on the cylinder in two layers. An auger, which turns slightly faster than the cylinder, moves the solids to the conic part of the unit where they are discharged.

Filtration/Presses
Filtraton/press systems press solids with rollers or screws against an opposing screen or belt and typically achieve a higher level of dewatering. The three main types are the roller press, the belt press and the screw press. A roller press uses two concave screens and a series of brushes or rollers to squeeze the liquid through the screen. A belt press uses a flat woven fabric that runs horizontally between squeezing rollers. The screw press system consists of a large screw which forces the slurry through a tube and past a cylindrical screen. A plug of manure is formed at the end of the tube. The flow of solids out of the tube is controlled by a set of pressure plates (Chastain et al. 1998).

With respect to agricultural slurries the most effective mechanical separators have employed a combination of separation principles.

2.3. Mechanical Separator Performance

An ideal mechanical solid-liquid separator is one that will remove a large percentage of solids from the liquid fraction and produce a solids fraction with a low moisture content (< 75%). Zhang and Westerman (1997) compiled available data on the performance of mechanical separators used to treat livestock waste. The data on swine waste separation units has been summarized and presented in Table 1.

Table 1. Summary of available mechanical separator performance results (Adapted from Zhang and Westerman, 1997)

Separator Type	Moisture Content of Solids (%)	Separator Efficiency (%) (on a mass basis)			
		TS	COD	TKN	TP
Stationary Screen	93	20	35	5	6
Vibrating Screen	84	20	18	21	26
Rotating Screen	86	10	7	8	6
Centrifuge	85	35	25	15	62
Belt Press	83	50	40	33	20

Stationary screens typically produce a solids fraction with a high moisture content and retain only a small fraction of the nutrients within the solids, however this option is usually the least expensive (Fleming, 1986). Rotating screens, especially, tend to have very low separation efficiencies (MWPS, 1997). Screen characteristics will greatly affect their performance. Smaller screen openings will generally yield a higher separation efficiency with respect to TS but the solids fraction will have a higher moisture content. Zhang and Westerman state that screen separators work most effectively when slurry TS concentrations are below 5% to avoid clogging. Ndegwa et al. (2000) suggested that screen separators would be of little use in treating swine waste as they typically do not remove small particles. Moller et al. (2000) also found that mechanical screen separators will only remove a small fraction of TN and TP and produce solids fractions with moisture contents > 85%.

As can be seen from Table 1 none of the systems which have been tested proved capable of producing a solids fraction with a moisture content < 80% on a consistent basis. Zhang and Westerman also cautioned that the data presented in Table 1 should be used with caution as the procedures and conditions under which equipment is tested will greatly affect their performance. Centrifuge systems can be capable of producing solids with relatively low moisture contents but are usually the most expensive option (Fleming, 1986). Centrifuges are also the most efficient system for removing TP (Moller et al. 2000). From Table 1, the belt press appears to possess the highest TS separation efficiencies and produces the driest solids fraction. Pieters et al. (1999) compared a filter press to a vibrating screen and a screw press and also found that the filter press had highest separation efficiency for swine waste. Fernandes et al. (1988) developed a belt microscreening unit that is continuously cleaned with air flow and reported TS separation efficiencies ranging from 47 - 59%. However, the moisture content of the solids fraction was still > 80%.

When Zhang and Westerman were conducting their review they noted that virtually no published information was available on the performance of screw presses. Screw presses are reportedly capable of producing solids fractions with moisture contents of 70% (MWPS, 1997). Since 1997, several studies have been published in which screw presses were evaluated in their ability to separate swine waste. Chastain et al. (1998) evaluated the Fan Separator, a commercial screw press system. The separator had a 0.5 mm screen and proved capable of producing a solids fraction with moisture contents ranging from 65 to 75%. The solids piled easily and gave off little odour. On average the system removed 16% of the TS, 12.5% of the TKN, and 16 of the TP from the liquid stream. The authors noted that TS, TP, and TKN removal increased with an increase in the TS concentration of the raw waste and concluded that the system worked most effectively when the swine slurry has a TS concentration of at least 50,000 mg/l. Moller et al. (2000) compared the performance of a screw press, a belt press and an inclined screen in separating swine manure. The screw press consistently produced solids with the lowest moisture content of all the separators, averaging 73%. Converse et al. (1999) evaluated another commercial unit, the KP-10 Vincent Screw Press. The unit comes equipped with a 0.5 mm bar screen. The moisture content of the solids fraction which was produced from the system ranged from 65 to 75%. The efficiency of the system, with respect to TS removal, was adequate (15 -30 %), however less than 5% of the TP was transferred to the solids fraction.

The cost of a mechanical solid-liquid separation sysem can range from $10,000 to $50,000. Currently available systems have relatively low separation efficiencies and the cost-effectiveness of applying these systems to swine wastes is still in question (Zhang and Westerman, 1997).

3. PROJECT OBJECTIVE

The objective of this project was to identify and evaluate a mechanical solid-liquid separator that could be feasibly be incorporated into a typical Nova Scotia swine farming system.

The system which was chosen for evaluation was the TR Separator. The TR separator employs a combination of scraped inclined screen and screw press separation principles. The TR Separator is built in Montreal and distributed by Blossum Agritec in North America. A representative from the NSDAF and several local hog producers attended the Toronto Farm Show and evaluated several commercially available swine waste separation systems. After visiting a hog farm in British Columbia that was using a TR separator they concluded that the TR separator would be the most promising system to evaluate.

4. METHODS

4.1. Description of the TR Separator

A schematic diagram of the TR separator is provided in Figure 1 (Appendix A). Manure is first pumped into an 8' x 8' x 4' concrete holding tank. A paddle/conveyor system moves the raw waste onto the inclined screen section. The inclined screen portion of the separator is 24' long and 2' wide. The screen is divided into three 8' lengths. The bottom section consists of a 1.8 mm stainless steel screen. The second 8' screen section has 1.0 mm holes, while the top 8' section is a solid piece of stainless steel sheet metal. The only function of the top section is to add length to the system enabling solids to be discharged at a higher elevation. This allows for the development of higher piles of dewatered manure. A flight of rubber paddles scrapes over the screen, momentarily removing solids that have and thus allowing liquid to sluice through. The paddles also act as a conveyor, moving the solids to the top of the screen section. At the top of the screen section is an 8" screw auger which provides further moisture removal from the solids fraction. A weighted cantilevered door provides pressure to squeeze out liquids. The system is controlled by a series of electrical floats and switches. Liquids that sluice through the screen are conveyed to a storage lagoon while the solids can be stored on a concrete pad. The makers of the TR separator claim that the unit can process up to 5000 gpm in flush barns and can produce a stackable solid product. The unit costs approximately $30,000, not including the additional expense of housing the system.

4.2. Description of Farm and Separator Set-up

The TR separator system was evaluated on a commercial swine farm located in Church Point, NS. The farm is a 600 sow operation and consists of three barns which house sows, weaner pigs, and feeder pigs, respectively. Manure slurries are stored in pits below the barns until full. The liquid manure flows by gravity to a small holding tank (Figure 2 - Appendix A). Before the installation of the separator the liquid manure would then be pumped into a three pond lagoon system. The TR separator was established between the pumping station and 1st lagoon as shown in Figure 2. The separated liquids flow into the 1st lagoon through an 8" PVC pipe while the solids are stored on a pad (enclosed by concrete walls on three sides) adjacent to the pumping station. Any liquids draining from the solid storage pile flow into the 3rd lagoon. The entire arrangement is enclosed in a heated building. A platform was also built to allow sampling of solids discharging from the screw auger. The submersible pump which moves the raw waste from the pumping station to the separator holding tank is tied into the separator control panel.

The primary holding tank was originally built 4' deep as specified by the manufacturer. However, it was found that a large portion of the solids were accumulating within the holding tank during initial operations of the separator. Therefore mid-way through the project the floor of the holding tank was raised to 1' below the elevation of the screen. A T-junction was also put in the inflow pipe to aid in distributing the raw manure within the separator holding tank. Results are presented for testing that occurred before and after these adjustments were made.

4.3. Sampling Protocol

Liquid manure from the sow, weaner and feeder barns were processed by the TR separator in separate trials. During the operation of the separator, samples were collected of the raw waste entering the separator holding tank, the liquid portion draining into the 1st lagoon, and the solid fraction discharging from the screw auger. A 5 L bucket was used to collect a sample of the raw waste each time the pump came on. Each time the pump turned on approximately 2.75 m^3 of liquid manure was sent to the separator. The volume of liquid waste processed by the unit was determined by recording the number of times the pump came on. Two 500 ml polyethylene bottles were filled each time the raw waste was sampled. Analysis of the raw waste included % dry matter, TKN, NH_3-N, TP, 5-day biochemical oxygen demand (BOD_5), TSS, potassium (TK), calcium (Ca), Magnesium (Mg), iron (Fe), Manganese (Mn), zinc (Zn), and copper (Cu). Samples of the separated liquid fraction were collected every 5 min. Every three samples were mixed to produce one composite sample every 15 mins. Two 500 ml polyethylene bottles were filled each time the liquid fraction was sampled. Analysis of the liquid fraction included the same parameters as the raw waste samples. The liquid fraction flow rate was recorded using an H-flume. Samples of the separated solids were also collected in 5 min time increments and composited every 15 mins. Samples were collected in plastic bags and analysis included % dry matter, total N, (TN), TP, TK, Ca, Mg, Fe, Cu, and Zn,. The Carbon:Nitrogen ratio (C:N) of each solid sample was also determined as the solid fraction was to be used as a compost material. All samples were immediately stored in ice-packed coolers and transported to a certified analytical laboratory for analysis.

5. RESULTS AND DISCUSSION

The ability of the TR separator to process each manure type was evaluated twice, once in 2000 and once in 2001. Samples collected in 2000 were taken before modifications were made to the separator. During the 2001 sampling of sow manure, the separator controls appeared to be malfunctioning, as the pump was erratically turning off and on. Flow information was not accurately obtained, therefore only concentration data are reported for this trial.

Characteristics of the raw manure and the separated liquid fraction are provided in Tables 1 and 2 for the 2000 and 2001 sampling trials, respectively. The raw manure possessed TS concentrations ranging from 3.4 to 8.1%. On average, the solid fraction which was produced represented 15% of the original volume of raw manure. Two parameters were calculated to gauge the efficiency of separator; the % reduction in concentration and the % of mass removed from the liquid fraction. Mass removal of TS ranged from 13 to 47 %. Mass removals of TS were greatest for weaner manure. The separator consistently removed greater than 20% of the TP from the liquid fraction. The separator was least effective in removing TK from the liquid fraction which is not surprising as K is usually found in the dissolved form (Bicudo, 2001). Nitrogen mass removal efficiencies ranged from 8 to 28%. These mass removal efficiencies are lower than those reported by Barrington (2000), who also performed an evaluation of the TR separator. During that study 50 to 60% of the manure solids were removed along with 50% of the TN and 35% of the TP. However, the manure was thoroughly agitated for 8 hrs prior to the separation trial. The mass removal efficiencies achieved by the TR separator during this study were still generally higher than the mechanical separators which were reviewed in Section 2.3.

The concentrations of pollutants remaining in the liquid fraction will determine the level of treatment/management required after the separation process. The TR separator was capable of reducing the concentrations of all the water quality parameters considering in this study, however reductions were low to modest at best. Five-day biochemical oxygen demand and TSS concentration reductions ranged from -9 to 56% and -11 to 18%, respectively. The negative reductions occurred during the 2000 weaner manure sampling trial and are considered suspect. Possible errors could have occurred during sampling or laboratory analysis. Concentrations of BOD_5 remaining in the liquid fraction were usually greater than 5000 mg/l. Concentration reductions of TN were minimal. Total N concentrations in the liquid fraction typically exceeded 2000 mg/l and was primarily in the NH_3-N form.

The liquid fraction produced from the TR separator would require an advanced level of treatment before being discharged to the environment. A natural treatment alternative, such as a constructed wetland or vegetated filter strip, would probably be incapable of handling an effluent of this nature. Ideally, the liquid fraction would be land applied at rates corresponding to crop nutrient requirements.

Table 2. Characteristics of the raw manure and the separated liquid fraction for 2000 sampling trials.

Manure Type	Raw	Liquid	% Concentration Reduction	% Mass Removal
Feeder				
TS (mg/l)	54000	40000	26	29
TP (mg/l)	922	736	20	23
TN (mg/l)	3448	3177	8	12
TK (mg/l)	1477	1534	-4	0.5
BOD_5 (mg/l)	13000	7523	42	-
TSS (mg/l)	13333	13200	1	-
Weaner				
TS (mg/l)	66000	36000	45	47
TP (mg/l)	894	799	11	22
TN (mg/l)	2761	2627	5	8
TK (mg/l)	1363	1320	3	6
BOD_5 (mg/l)	9640	10503	-9	-
TSS (mg/l)	4567	5100	-11	-
Sow				
TS (mg/l)	34000	26000	24	35
TP (mg/l)	837	568	32	43
TN (mg/l)	2251	1959	13	26
TK (mg/l)	905	847	6	21
BOD_5 (mg/l)	10747	4730	56	-
TSS (mg/l)	6467	5900	9	-

Table 3. Characteristics of the raw manure and the separated liquid fraction for 2001 sampling trials.

Manure Type	Raw	Liquid	% Concentration Reduction	% Mass Removal
Feeder				
TS (mg/l)	81100	76800	5	13
TP (mg/l)	1500	1200	20	22
TN (mg/l)	4300	3800	12	18
TK (mg/l)	1854	1751	6	13
BOD_5 (mg/l)	22620	23737	-5	-
TSS (mg/l)	-	-	-	-
Weaner				
TS (mg/l)	50700	45300	11	28
TP (mg/l)	500	400	20	32
TN (mg/l)	2000	1800	10	28
TK (mg/l)	1058	1004	5	23
BOD_5 (mg/l)	3657	3304	10	-
TSS (mg/l)	11961	9813	18	-
**Sow*				
TS (mg/l)	70900	66700	-	-
TP (mg/l)	300	400	-	-
TN (mg/l)	1400	1600	-	-
TK (mg/l)	502	877	-	-
BOD_5 (mg/l)	5007	4963	-	-
TSS (mg/l)	6220	8370	-	-

*Separator controls were malfunctioning

It should also be noted that the pollutant concentration reductions achieved by the TR separator are lower than those achieved through conventional lagoon systems. Anaerobic lagoons typically achieve TS and BOD_5 reductions of 60 and 50%, respectively (Barker, 1996; Chastian et al. 1998). Nitrogen reductions in lagoon systems are usually greater as well, however the majority of N removal presumably occurs through NH_3-N volatilization due to anaerobic conditions..

The separator manure processing rates for each of the trials are presented in Table 4. The manufacturers of the TR Separator claim that the system is capable of processing 5000 gpm ($\approx$1100 m^3/hr) of liquid manure from a flush system. The highest processing rate observed during this study was 15 m^3/hr. Barrington's study reported that the TR separator processed 1.5 m^3 of liquid swine waste in 30 mins.

Table 4. Manure processing capacity of the TR Separator

	Processing Capacity (m^3/hr)	
Manure Type	2000 Sampling Trials	2001 Sampling Trials
Feeder	12.5	8.5
Weaner	9	15
Sow	15	-

The characteristics of the separated solid fraction are provided in Table 5 and 6 for the 2000 and 2001 sampling trials, respectively. As stated in Section 2.1, a solid dry matter content of at least 20% is required so that the material can be easily piled and moved with solid manure handling equipment. Four of the six sampling trials produced solids that had a dry matter content less than 20%. It was also visually observed that the solid fraction did not stack and that there was significant runoff from the pile during these sampling trials.

The C:N ratio of the separated solids ranged from 9.5 to 19. The optimum C:N ratio range for composting is 20:1 to 30:1, therefore a carbon amendment would have to be added to the separated solids to facilitate the composting process. Barrington (2000) Found that the TR separator was capable of producing solids with a dry matter content of 15%. The TR separator performance, with respect to producing a relatively dry solids fraction, is less efficient than the two commercial screw press separators (Fan Separator, KP Vincent Screw Press) which were reviewed in Section 2.3. One should use caution, however, when comparing separators which have been tested under different conditions.

Table 5. Characteristics of the separated solid fraction for the 2000 sampling trials.

	Manure Type		
Parameter	Feeder	Weaner	Sow
% DM (Raw Manure)	5.4	6.6	3.4
% DM (Separated Solids)	15.5	22.6	15.9
C:N Ratio	13	19	17
TP (mg/kg)	1711	1849	2720
TN (mg/kg)	4825	4606	6533
TK (mg/kg)	1601	1305	1972

Table 6. Characteristics of the separated solid fraction for the 2001 sampling trials.

	Manure Type		
Parameter	Feeder	Weaner	Sow
% DM (Raw Manure)	8.11	5.07	7.09
% DM (Separated Solids)	16.1	16.8	23.1
C:N Ratio	9.5	14	17
TP (mg/kg)	2500	2000	3200
TN (mg/kg)	5400	4300	5000
TK (mg/kg)	1748	1040	980

There are several aspects of the set-up and operation of the TR separator that could be adjusted to possibly achieve improved performance. First, the slurry was not entering the separator as a homogeneous mixture. A basic requirement for the efficient separation of swine manure is the continuous agitation of the effluent that is to be processed (Bicudo, 2001). Otherwise, solids will settle out in the holding tank. The farmer has purchased and recently installed an agitator in the initial manure holding pit. This should help keep solids in suspension while they are being pumped to the separator unit.

The manufacturer also states that the TR separator is most efficient when processing fresh manure (i.e. before appreciable anaerobic decomposition of manure solids has occurred). Glerum et al. (1970) state that during the biological degradation of pig slurry, the content of dry matter usually rises quickly because of incomplete decomposition of organic matter and that separation may be limited when dry matter contents reach greater than 2 to 3%.

Barrington (2000) reported that if the screen perforations were reduced to 0.1 mm, as much as 80% of the TS, 65% of the TN could, and 60% of the TP could be retained within the solid fraction. This information was obtained through bench scale experiments, however, and the report did not include data on the % dry matter of the separated solid fraction. A smaller screen perforation would probably result in a wetter solid fraction.

6. CONCLUSIONS

- The TR separator performed well, as compared to results that have been published on the performance of other mechanical solid-liquid separation units. The TR system usually removed greater than 20% of the TS and TP from the raw liquid manure. The solid fraction represented approximately 15% of the original volume of manure.

- The TR separator did not produce a solid fraction that could be piled. Dry matter contents of the separated solid fraction were usually below 20%. A dry, carbon based material, such as sawdust or straw, would have to be added to the solid fraction to achieve moisture contents and C:N ratios necessary for composting.

- With respect to decreasing pollutant concentrations within the separated liquid fraction, the TR separator did not achieve concentrations reductions typical of conventional lagoon systems. The effluent would require significant treatment before it could be discharged to the natural environment. A mechanical separation system might be more beneficial if the farmer intended to irrigate the liquid fraction onto cropland. Removal of the larger solids would enable the farmer to pump and convey the effluent through irrigation equipment without first having to treat it in land-intensive lagoon systems.

- It is doubtful that the system will result in a significant decrease in odour production as the majority of the odour causing material remained in the liquid fraction after the separation process.

- Continuous agitation of the raw manure as it is being pumped to the separator, and the use of fresher manure, may enhance separation efficiencies.

- The economic benefit of using a mechanical solid-liquid separator to process swine manure will largely depend on the potential for solids reuse and value recovery.

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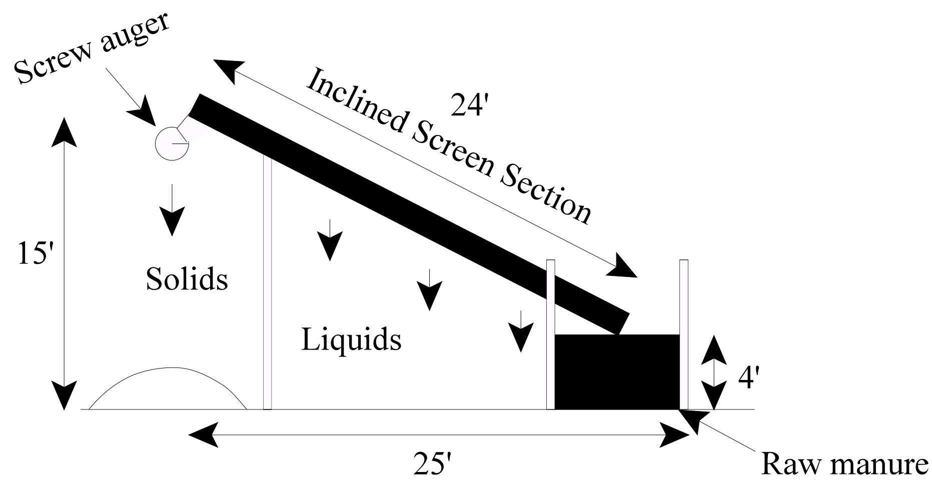

Figure 1. Schematic representation of the TR Separator

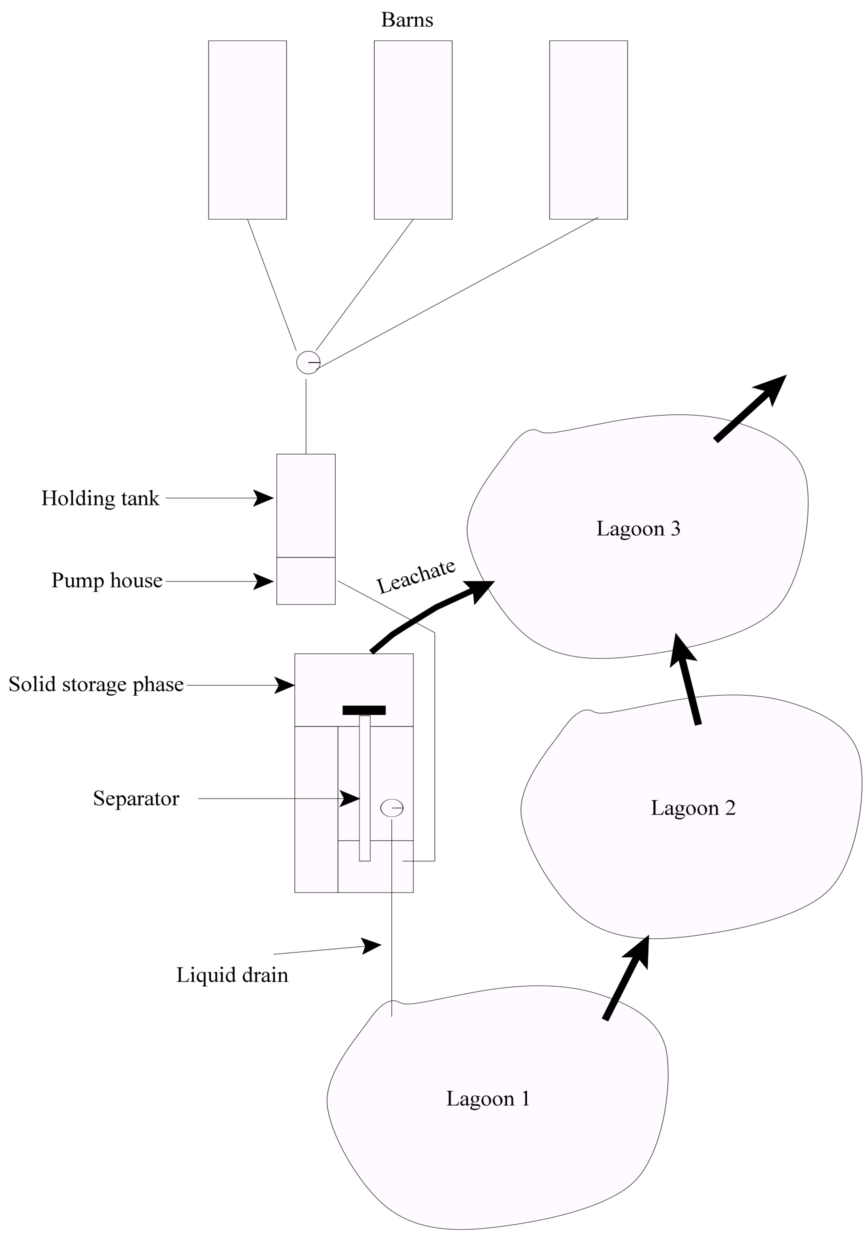

Figure 2. Layout of farm and waste management system