Atlantic SWINE RESEARCH PARTNERSHIP Inc.

Nova Scotia Agricultural College

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factsheet

Understanding Mechanical Solid-Liquid Manure Separation

Introduction

Liquid manure handling systems are popular for livestock production because of their ease of mechanization and low labour requirements. These systems however, typically produce large volumes of diluted waste. The cost of transporting this extra material to arable land can be high, therefore it is usually stored and partially treated in large anaerobic lagoons. The storage of high strength waste slurries in 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.

It is desirable to concentrate the nutrients from liquid manure for several reasons, including: (i) odour reduction, (ii) decreased loading on lagoons and other treatment systems, and (iii) the production of a valuable, easily manageable, nutrient rich, solid product.

An inclined screen separator.

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, relatively few have been applied to agricultural systems.

Important Liquid Manure Characteristics

Before choosing a separation technology it is first important to understand the physical and chemical characteristics of the material which is being treated. A good separation system must be capable of transferring a large mass of nutrients and organic matter to the solid fraction. Important waste characteristics that must be considered are: (i) the particle size distribution; and (ii) the distribution of nutrients and organic matter within each particle size class.

The total solids (TS) content of liquid manure is made up of both total suspended solids (TSS), and total dissolved solids (TDS). The TSS fraction is the solids component which mechanical separators are designed to remove. 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. Therefore, mechanical separation systems are generally more effective in treating liquid cattle waste than swine manure.

Phosphorus (P) is generally the nutrient that is most easily removed by liquid-solid separation because it is relatively insoluble and mainly associated with the solid fraction. The primary nitrogen (N) form within swine manure is ammonium (NH_4^+). Both NH_4^+ and potassium (K) are soluble and usually associated with liquid fractions. Therefore, in comparison to P, physical separation will transfer little N and K to the solid fraction.

As well as removing a substantial 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.

Separators

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

Screens
(Stationary, Vibrating, 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.

A vibrating screen consists of a flat circular screen that vibrates. Liquids pass through the screen while solids that remain 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, perforated drum that spins. 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 scraped into a collection area. This design is the most efficient with respect to keeping the screen holes open. Screens typically only achieve solids fractions with moisture contents between 85 and 95%.

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. Rotating screens, especially, tend to have low separation efficiencies. 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.

Centrifuges

Centrifuge separators typically consist of a horizontal or vertical cylinder which is continuously 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 a discharge location where they are collected.

Centrifuge systems are capable of producing solids with relatively low moisture contents but are usually the most expensive option. They generally tend to be the most efficient system for removing P.

Filtration or Presses

Filtration/press systems press solids with rollers or screws against an opposing screen, or belt, and typically achieve a high level of dewatering. The three main types are roller presses, belt presses, and screw presses. 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.

Of all the separators that have been tested, the belt press has produced the best results in terms of separating a large portion of total solids. However, the belt press usually produces a solids fraction with moisture contents > 80%. Screw presses are reportedly capable of producing solids fractions with moisture contents of 70%. Two commercial screw press systems, the Fan Separator and the KP-10 Vincent Screw Press, have been evaluated with swine waste, producing solids fractions with moisture contents ranging from 65 – 75%.

Combination Systems

With respect to agricultural slurries the most effective mechanical separators have employed a combination of separation principles. One common example would be the submerged scraped screen system. A tank containing an inclined screen is filled with liquid manure. Larger solids settle quickly onto the surface of the screen, while liquids sluice through. The larger solids then act as an additional filter, trapping smaller particles. The solids are continually scraped towards the top of screen where they are discharged from the system.

The TR Separator, manufactured by Blossom Agritec, is another example of a combination system. It consists of a submerged scraped screen and a screw press (Figure 1). The TR Separator was tested on a commercial hog farm by the NSAC and Pork Nova Scotia. The system was capable of transferring 30% of the P and 25% of the TS in the raw manure to the solid fraction. During the trials however, the system did not produce a stackable solid fraction (>80% moisture).

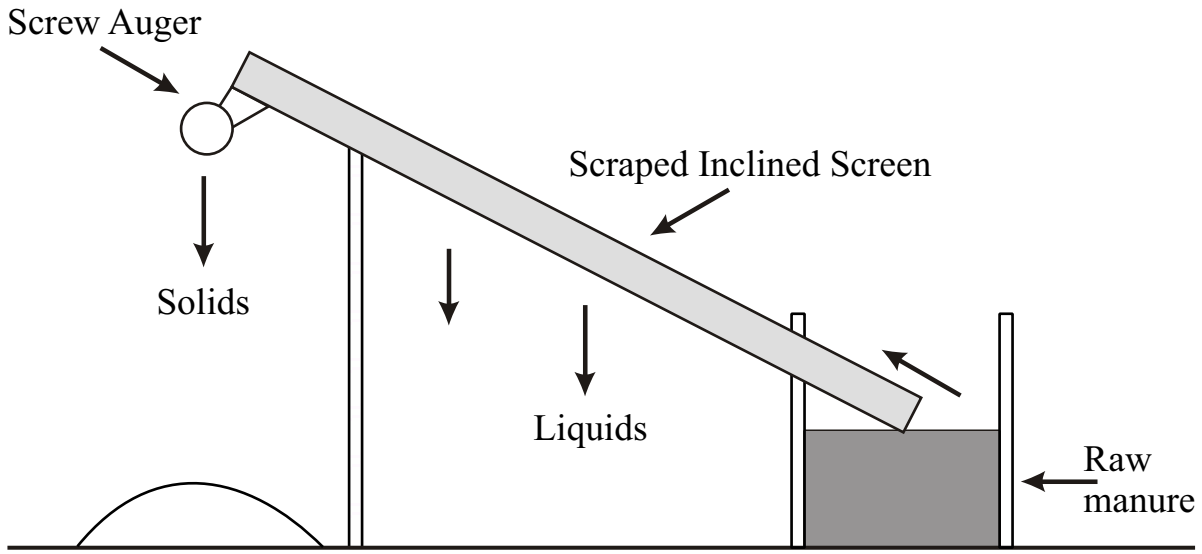


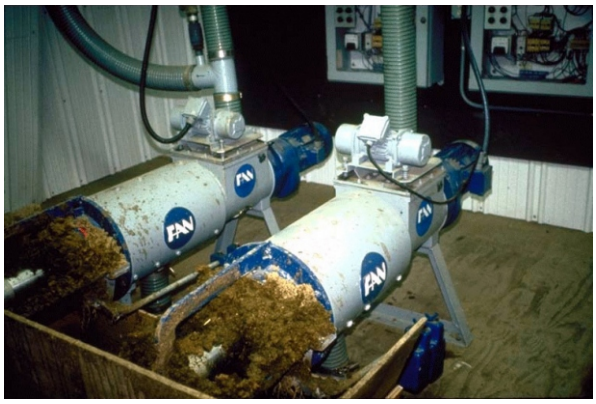
Figure 1. Schematic of the TR manure separation system that is currently being used by Atlantic Canada hog producers.

Summary

The cost of mechanical liquid-solid separation systems can range from $10,000 – $50,000. Separating out a portion of the solids from liquid manure would be beneficial for several reasons such as: (i) reducing the possibility of clogging pipes, and (ii) producing a valuable solid material that can be easily stored or field applied.

There are disadvantages, or limitations, of mechanical liquid-solid separation which include: (i) their cost, (ii) the need for regular maintenance and management, and (iii), the liquid fraction which is produced still requires treatment before it can be discharged. With respect to decreasing pollutant concentrations within the separated liquid fraction, mechanical separators do not achieve concentration reductions typical of conventional lagoon systems

A mechanical separation system might be more beneficial if the farmer intended to irrigate the liquid fraction onto crop land. 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. The economic benefit of using a mechanical solid-liquid separator to process liquid manure will largely depend on the potential for solids reuse and value recovery.



Screw presses.

For more information

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