Technologies for Recycling Animal Manures

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Extended Abstract

Modern agriculture has made many improvements in the production of safe and affordable food. A significant part of this advance is effective confined animal production. In the case of swine and dairy production, the waste has been managed in varying degrees with liquid systems. Unfortunately, these systems have significant waste management challenges. This paper focuses on challenges associated with swine production that include 1) generation of large amounts of waste with its attendant pathogens, 2) anaerobic lagoon and spray field technology with its associated environmental limitations and prevalence in parts of the USA and the world, 3) N and P in excess of crop area available for disposal, and 4) potential and significant odor and ammonia emissions problems. Specifically, this paper presents information on technologies that are being developed to allow the production of swine with improved recycling of water, transformation of N, recovery of P, and destruction of pathogens.

One method of reducing N and P from lagoon systems is to retrofit the lagoon, but there are several problems with this approach. Among the problems with nitrification via simple aeration of the lagoon is the fact that nitrification requires high levels of nitrifying bacteria which do not exist in the lagoon. Thus, simple aeration is not very effective in the use of oxygen, and the aeration strips ammonia which exacerbates emissions problems. Moreover, if one simply tries to raise the pH and precipitate the P from the lagoon wastewater, there are three basic problems: 1) the lagoon is buffered by both ammonia and carbonate, 2) large quantities of alkali are required to raise the pH of the buffer wastewater, and 3) when the pH is raised there is enormous volatilization of ammonia.

However, with a protocol developed by USDA-ARS, ammonia is effectively transformed to nitrate, P is recovered, and pathogens are destroyed (patent pending, USA Patent serial 09/903,620). A solution to the problem of nitrifying bacterial biomass has been found by using encapsulated nitrifying bacteria to establish a reactor with sufficient nitrifying bacteria to convert the ammonia to nitrate without the problems of ammonia volatilization (Fig. 1, Vanotti and Hunt, 2000; Vanotti et al., 2000). The nitrified wastewater can be sent through a denitrification cycle if the producer has problems with excess N, or it can be conserved and used in the nitrate form. The next step is to recover the P as a useful product, i.e., calcium phosphate. Once nitrification has been completed, the problem of ammonia volatilization has been eliminated as well as the pH buffering by ammonia. Furthermore, the acidity produced by the nitrification process consumes most of the carbonate buffering capacity of wastewater. At this point, a small amount of liquid lime can raise the pH to greater than 10 and precipitated calcium phosphate can be recovered (Fig. 2, Vanotti et al., 2001 and 2002). The amount of P removal can be matched to the crop and land, i.e., nearly all of the P can be removed or a desired N/P ratio can be established in the wastewater. In addition, raising of the pH to greater than 10 produces conditions that kill typical wastewater pathogens (Table 1, Vanotti et al., 2001).

In contrast to systems that use slow anaerobic digestion of waste in lagoons, systems that use quick separation of solids and liquids can conserve much of the organic fraction of animal waste. However, to effectively recover the solids, some form of flocculation must be used. We have found polyacrylamides to be effective (Fig. 3, Vanotti and Hunt 1999; Vanotti et al., 2002). The flocculated solids can be effectively removed by various systems. Examples of systems that effectively remove polyacrylamide-flocculated animal waste are 1) a filter press by a French company, Ecoliz, 2) a rotating filter press by a Spanish company, Selco, and 3) a sand filtration process system by a USA company, The David Deskins Company. The solids can be composted on site or transported to a central processing plant where they can be stabilized, blended, and marketed. Once the solids are removed, a relatively small amount of waste remains to be treated in the wastewater by the nitrification/denitrification, P recovery, and pathogen destruction, as have been previously described. After treatment, the majority of the wastewater can be recycled to the animal production facility, and a small fraction of the treated wastewater can be applied to land.

The solids removal and wastewater treatment with recycling allows much of the waste to be managed as a resource in a stable solids form. This form of solid waste is much easier to distribute and apply in socially and environmentally acceptable manners. It also allows relatively small amounts of soluble N and P to be treated and/or recovered in an effective manner. Thus, substantial amounts of P can be recycled. The treated wastewater returning to the animal facility does not present noxious emissions problems for the animals, workers, or the public; and it does not present problems of excess nutrient or pathogen application to land. Furthermore, there are no huge quantities of wastewater for potential spills. Thus, environmental risks are minimized and resources are more effectively recycled.

References

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Figure 1. A schematic of wastewater nitrification using polyethylene glycol immobilization of nitrifying bacteria (Vanotti and Hunt, 1999).

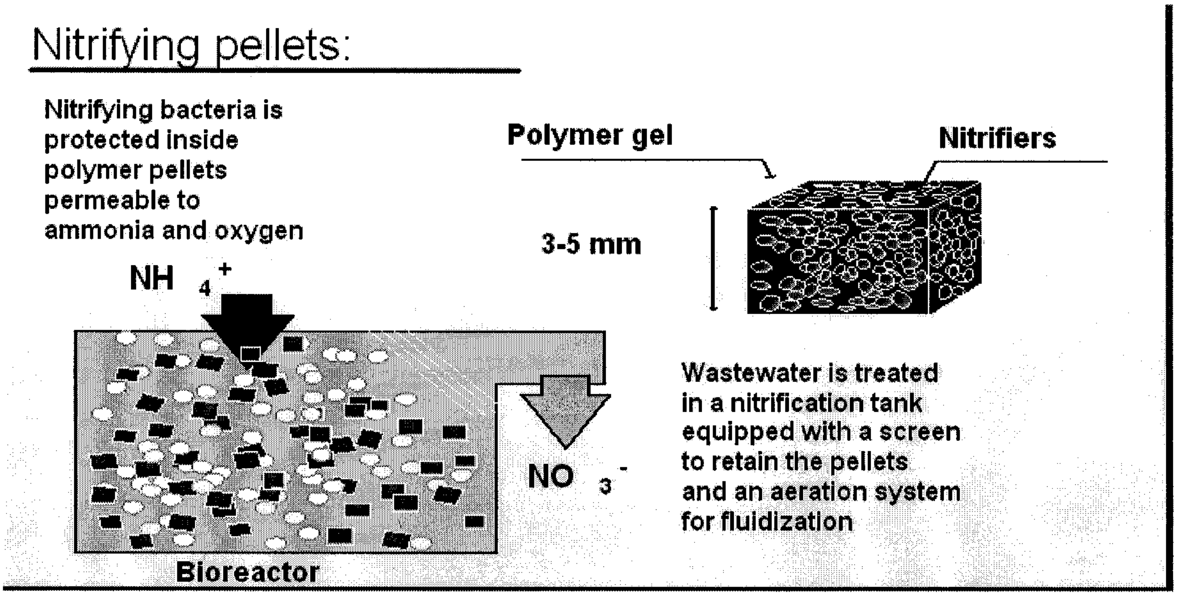

Figure 2. Phosphorus removal via a new method (Vanotti et al., 2001).

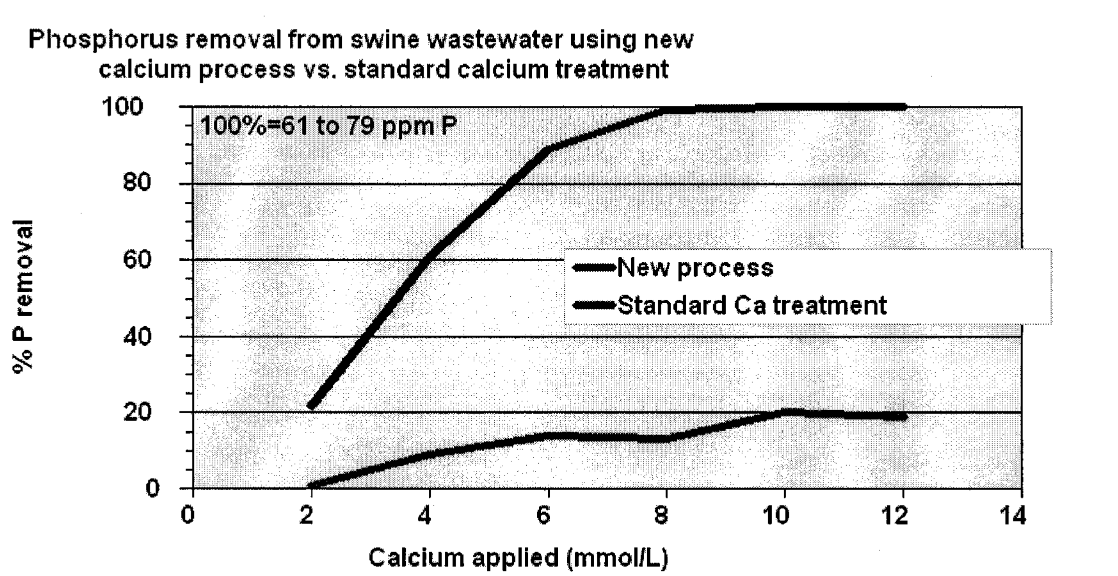

Figure 3. Swine solids removal with Polyacrylamides (Vanotti et al., 1999) .

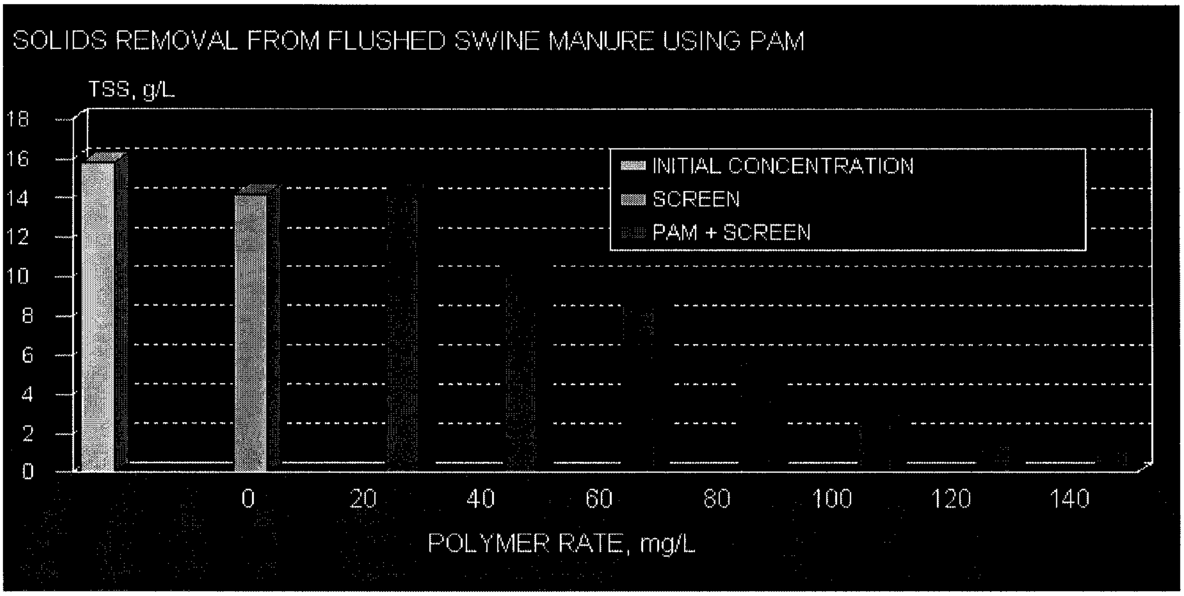

Table 1. Pathogen reduction from various processes of swine wastewater treatment (Vanotti et al, 2001).

Pathogen reduction by system

Treatment point	Enterococci #cfu/mL	Salmonellae #cfu/mL
Raw Manure	952,000	23,200
Solids Separation	159,000	7,210
Nitrification/ denitrification	41	310
Phosphorus treatment	0	0

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