MANURE TREATMENT FOR GREEN FARMING SYSTEMS OF THE SOUTHEASTERN USA

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1 INTRODUCTION

Although most of the farms of the southeastern USA are relatively small, they often have profit centers of livestock or high value crops (Kemper et al., 2006). This livestock production is vital to the regional economy. It is common for more that 50% of the agricultural cash receipts for states of this region to come from livestock. For the emerging green framing systems, the livestock manures are critical components of a more profitable and green farming systems. For this superior possibility to be realized, the desired farming-system management of livestock waste must be made environmentally benign and sustainable. This can be done with existing and emerging technologies that 1) extract and recycle excess nutrients (Szogi et al., 2008; Vanotti et al., 2003), 2) destroy pathogenic microbes and pharmaceutically active compounds (Vanotti et al. 2009), 3) produce bioenergy (Cantrell et al., 2008), and 4) create carbon and other natural resources credits (Ribaudo et al., 2007; Vanotti, et al. 2008). Many of the bioenergy conversion technologies will be compact and thermochemical (Cantrell et al., 2008; Ro et al., 2009). The transformed manure will be pathogen and pharmaceutically active compound free. The thermochemical technologies can convert blends of wood, grass, and livestock manure feedstocks into energy. They will also produce a range of products including biochar that can be used to build soil quality and create carbon credits (Novak et al., 2009). The patented Pyrogen™ pyrolysis technology has shown important potential for producing these products. The wood feedstocks produce biochars that are high in carbon for building soils and create carbon credits. The manure feedstocks produce nutrient-dense soil amendments suitable for supplying crop nutrients. While advance in technology, policy, and businesses models will be required, there is significant opportunity for advancement into such green farming systems.

2 DISCUSSION

A schematic of a green farming system is presented in Figure 1. Parts of the system are well advance and are being used on farms. Others are in the developmental phases. One of the most advanced parts is the swine wastewater treatment system (Vanotti et al. 2009). The technology is a cost-effective method of treatment alternative to open lagoons, which is the common method of handling hog wastes throughout the USA. The technology has changed the way of thinking about manure management by solving multiple challenges in modern livestock production. These challenges include atmospheric emissions, excess nutrients (nitrogen and phosphorus), pathogens and food safety, odors, and affordability of treatment. The on-farm system uses solid-liquid separation and nitrogen and phosphorus removal processes (Vanotti et al., 2010). This new technology produces significant direct benefits to the producers (Vanotti et al., 2009). As a result of the cleaner environment in the barns brought about by the new technology, the animal health and productivity is improved. Industry data showed three major impacts in productivity: i) swine daily weight gain increased, ii) feed conversion improved, and iii) animal mortality decreased. As a consequence, 5 to 6 percent more hogs were sold per growing cycle (Szogi and Vanotti, 2008). In addition, the new technology dramatically reduces greenhouse gas (GHG) emissions and ammonia emissions. For example, replacing the lagoon with the new technology reduced GHG emissions by 97%, allowing farmers to earn money in emerging carbon trading markets (Vanotti et al., 2008). This important benefit of the technology is a key additional source of income for swine producers adopting the technology with voluntary carbon markets as well as cap-and-trade national legislation. Another potential direct benefit to farmers is the trading of water quality credits (nitrogen and phosphorus) within a watershed (Ribaudo et al., 2007). With 50 nutrient credit programs already established throughout the USA, it may be that water quality credits will be important to livestock producers adopting new manure treatment technologies.

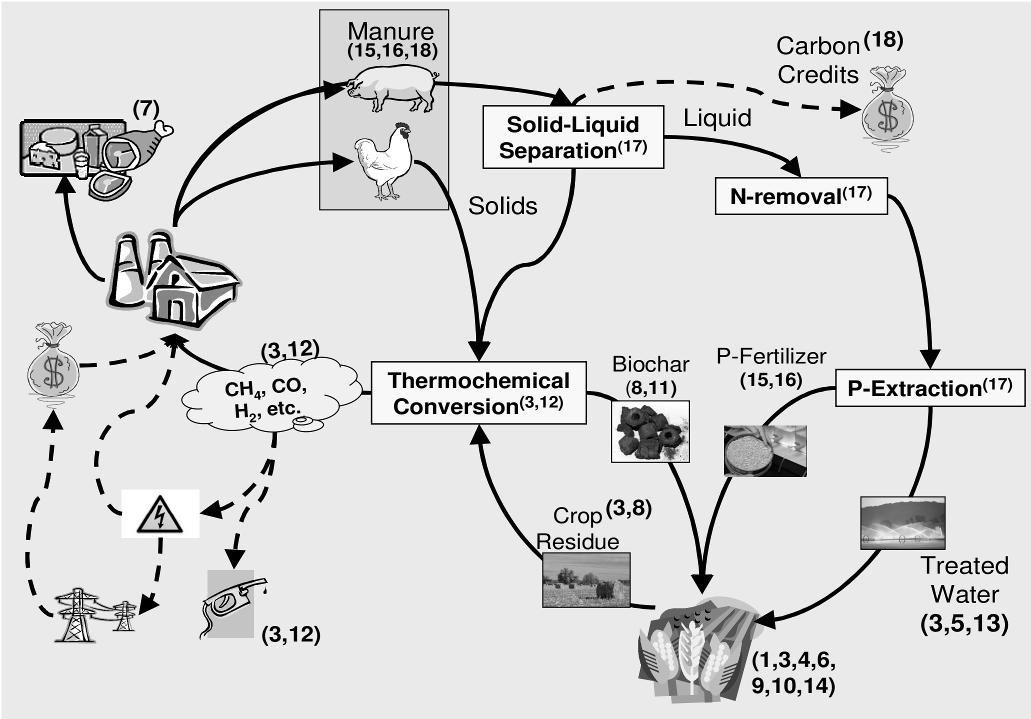

FIGURE 1 **A schematic of a green farming system that utilizes livestock manures and thermochemical conversion for manure treatment, energy, and byproducts.**

With lower organic and nutrient concentrations in the treated swine wastewater, the lagoons became clean: blue-water-lagoons. This allows more versatility in the use of the lagoons as resources for storage of irrigation water. This is an important aspect of the system for both grain and bioenergy (Stone et al., 2008). Stone et al. (2008) conducted a study in North Carolina comparing treated effluent with conventional fertilizers for bermudagrass production. They found using treated swine wastewater effluent produced significantly higher bermudagrass hay yields. Coastal bermudagrass hay produced from swine waste that was processed directly through a waste treatment facility and the liquid fraction delivered via subsurface drip irrigation was readily consumed by wether sheep. Hays produced from chemical fertilizer were consumed in greater amounts compared with subsurface drip irrigation. Cantrell et al. (2008) analyzed the biomass samples from the Stone et al. (2008) study for the energy content and found with the increased biomass quantity, there was more biomass energy potential from the bermudagrass grown with treated wastewater effluent.

As with traditional biological methods, thermochemical conversion (TCC) technologies in livestock waste-to-bioenergy treatments can provide livestock operators with multiple value-added, renewable energy products (Cantrell et al., 2008). These products can meet heating and power needs or serve as transportation fuels. The TCC processes of pyrolysis which proceeds in the absence of oxygen can convert both swine and poultry manures. Using the Pyrogen™ pyrolysis unit, functional chars have been produced. The energy values of the produced gases were generally comparable to natural gas, and the biochar energy content was generally comparable to coal (Table 2). The Pyrogen™ pyrolysis unit is operated in conjunction with an electrical generator that is capable of using the generated syngases for production of electricity. With generally clean feedstocks, its exhaust gases typically meet high emission standards. Moreover, the produced biochar could be used as a manure-based-fertilizer that had been treated with temperature that would be consistent with complete pathogen kill and pharmaceutically active compound destruction. A pyrolysis machine such as the Pyrogen™ , could also convert crop residues and wood feedstocks to energy and biochar. Such biochar has been shown to improve important soil quality aspects of soils (Novak et al, 2009).

TABLE 2 **Characteristics of pyrolysis gas and biochar from swine and poultry manures.**

Manure origin	Raw Feedstock Energy Content MJ/kg	Biochar Energy Content MJ/kg	Biochar Recovery % initial mass	Gas Energy Content MJ/m^3	Gas Production L/kg initial
Swine Solids	19.57	18.32	42.1	29.42	266
Poultry Litter	13.06	13.52	43.6	14.97	246

3 CONCLUSIONS

Livestock, particularly poultry, is a huge component of the Southeastern USA economy. Yet, the management and treatment of this manure is becoming increasingly difficult via classical methods. There is also much interest in bioenergy in the southeast where cellulosic energy is advantageous. Technologies and treatment methodologies are now emerging that will allow manure management and bioenergy to be synergistically advanced. Pyrolysis offers the advantage of adaptability to multiple feedstock as well as destruction of pharmaceutically active compounds and complete kill of pathogens. Moreover, it produces a potentially important soil-carbon-building amendment, biochar. With astute advancement in technology, policy, and businesses models, there is significant opportunity for advancement of profitable and sustainable green farming systems.

REFERENCES

Cantrell KB, Ducey T, Ro KS, Hunt PG 2008. Livestock waste-to-bioenergy generation opportunities. Bioresour. Technol., 99(17), p. 7941-7953.

Kemper NP, Popp JS, Goodwin Jr HL, Miller WP, Doeksen GA 2006. The economic power of poultry in the ozarks. J. Appl. Poult. Res., 15(4), p. 502-510.

Novak JM, Busscher WJ, Laird D L, Ahmedna M, Watts D W, Niandou M A S 2009. Impact of Biochar Amendment on Fertility of a Southeastern Coastal Plain Soil. Soil Sci 174(2): p. 105 -112.

Ribaudo M, Johansson R, Jones C 2007. Environmental credit trading: Can farming benefit? In: Amber Waves: the economics of food, farming, natural resources, and rural America. Perspectives on Food and Farm Policy: Conservation. May 2007. Economic Research Service/USDA.

Ro KS, Cantrell KB, Hunt PG, Ducey TF, Vanotti MB, Szogi AA 2009. Thermochemical conversion of livestock wastes: Carbonization of swine solids. Bioresour. Technol., 100 (22), 5466-5471

Stone KC, Hunt PG, Millen JA, Johnson MH, Matheny TA, Vanotti MB, Burns JC 2008. Forage Subsurface Drip Irrigation Using Treated Swine Wastewater. Trans. ASABE 51(2):433-440.

Szogi AA, Vanotti MB, Hunt PG, 2008. Phosphorus recovery from poultry litter. Trans. ASABE, 51(5): p. 1727-1734.

Szogi AA, Vanotti MB 2008. Enhanced Animal productivity and health with Improved manure management in 2nd Generation Environmentally Superior Technology in North Carolina: II. Air Quality. p. 523-527. In: VIII International Livestock Environment Symposium Aug. 31st – Sep. 4th, Iguassu Falls, Brazil, CDRom, ASABE, St. Joseph, MI.

Vanotti MB, Szogi AA, Hunt PG 2003. Extraction of soluble phosphorus from swine wastewater. Trans. ASAE, 46(6): p. 1665-1674.

Vanotti MB, Szogi AA, Fetterman LM 2010. Wastewater treatment system with simultaneous separation of phosphorus and manure solids. U.S. Patent 7,674,379 B2. U.S. Patent and Trademark Office, Washington, DC.

Vanotti MB, Szogi AA, Millner PD, Loughrin JH 2009. Development of a second-generation environmentally superior technology for treatment of swine manure in the USA. Boresour. Technol. 100(22):5406-5416.

Vanotti MB, Szogi AA, Vives CA 2008. Greenhouse gas emission reduction and environmental quality improvement from implementation of aerobic waste treatment systems in swine farms. Waste Manage.28(4):759-766.