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PRODUCER BENEFITS USING TERRA BLUE TREATMENT TECHNOLOGY: INCREASED PIG PRODUCTIVITY, EXPANSION, AND CARBON CREDITS

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Abstract. The State of North Carolina and USDA NRCS's Environmental Quality Incentives Program started a statewide Lagoon Conversion Program (LCP) that provides financial support to livestock farmers installing Environmentally Superior Technology (EST) for manure management. A second-generation treatment system for swine waste was demonstrated that achieved the high treatment performance of an EST, yet it is much more economical than earlier versions. A U.S. Patent 7,674,379 was issued in 2010. The new technology is being commercialized by Terra Blue Inc., of Clinton, N.C. The system used solid-liquid separation and nitrogen and phosphorus removal processes that replaced traditional anaerobic lagoons with a system that produces a clean, deodorized, and disinfected effluent. It was the first system certified by the State of North Carolina as an EST due to its efficacy in reducing problems of ammonia emissions, excess nitrogen and phosphorus, pathogens, odors, and heavy metals. The revamped system met EST standards at one-third the cost of the previous version. In cleaning up manure wastewater, the system removed almost 100 percent of pathogens and odor-causing components, 95 percent of total phosphorus, 97 percent of ammonia, and more than 99 percent of heavy metals copper and zinc. The new system also cut emissions of methane and nitrous oxide—powerful greenhouse gases—by 97 percent. This technology was featured as an example of five carbon-reducing technologies that can quickly create green jobs in America in the report "Manufacturing Climate Solutions: Carbon-Reducing Technologies and U.S. Jobs." Animal health and production also benefited: swine daily weight gain increased 6.1%, feed conversion improved 5.1%, and animal mortality decreased 47%. Using the second-generation system instead of the lagoon system, the farmer sold 61,400 pounds more hogs –a 5.8% increase- per growing cycle. Due to the reduced environmental footprint of the innovative animal waste management system, farmers in North Carolina are allowed to expand the operation, about twice the pigs in the same land.

Introduction

The new wastewater treatment system was developed to replace the anaerobic swine lagoon technology commonly used in the USA to treat swine waste (Vanotti et al., 2009; LCP, 2007). The system is commercialized by Terra Blue, Inc. of Clinton, NC (Note: before August 2010, the company was called Super Soil Systems USA, and the treatment system was referenced as the "SuperSoil" system). It combines solid-liquid separation,

biological ammonia treatment and phosphorus recovery, which are done on-farm (Vanotti et al., 2009), and composting of the separated manure solids, which is done in a centralized facility (Vanotti et al, 2006). The composting process used a mixture of manure and cotton gin residue. This combination of aerobic processes substantially eliminated the release into the environment of odors, pathogens, ammonia, greenhouse gases, and heavy metals. It also produced a deodorized and disinfected liquid effluent that can be used for flushing the barns and for crop irrigation, along with value-added organic products from the solids for use in horticultural markets.

The system met the criteria of an environmentally superior technology (EST) as determined by an agreement between government and swine industry to find technologies that could replace the lagoon system (Williams, 2006). The environmental performance standards of an EST are the following: (1) eliminate the discharge of animal waste to surface waters and groundwater through direct discharge, seepage, or runoff; (2) substantially eliminate atmospheric emissions of ammonia; (3) substantially eliminate the emission of odor that is detectable beyond the boundaries of the swine farm; (4) substantially eliminate the release of disease-transmitting vectors and airborne pathogens; and (5) substantially eliminate nutrient and heavy metal contamination of soil and groundwater. The first-generation technology was demonstrated full-scale during 2003-2004 in Goshen Ridge farm, a 4,400-head finishing farm in Duplin County, NC. It was determined as an unconditional EST for new farms which are permitted and constructed for the first time after March 2005 and for expansion of existing swine farms (Williams, 2006). Recommendations were also made to evaluate an improved, redesigned second-generation version of the wastewater treatment system. Therefore, a lower-cost, second-generation treatment system was designed and demonstrated full-scale in 2006-2007. Demonstration of the second-generation EST was done on B&B Tyndall farm, a 5,150-head finishing swine operation in North Carolina (Figure 1)

Figure 1. Aerial view of the second-generation Terra Blue swine waste treatment system. The system treated all the manure flushed from seven barns containing a total of 5,145 finishing pigs.

New Wastewater Treatment System

The on-farm system uses solid-liquid separation, biological nitrogen removal, and disinfection and phosphorus removal unit processes linked together into a practical system for livestock operations (Figure 2). The system greatly increases the efficiency of solid-liquid separation with flocculation of the suspended solids using polymer. Nitrogen management to eliminate ammonia emissions is accomplished by passing the liquid through a biological module containing nitrification and denitrification bacteria adapted to high-ammonia wastewater. Subsequent alkaline treatment of the liquid in a phosphorus removal module precipitates phosphate and kills pathogens. The phosphorus precipitate is simultaneously separated with the manure. The system recycles clean water to flush the barns. The treated water is stored in the former lagoon and used for crop irrigation. The solids are removed from the farm, composted and used for the manufacture of value-added products.

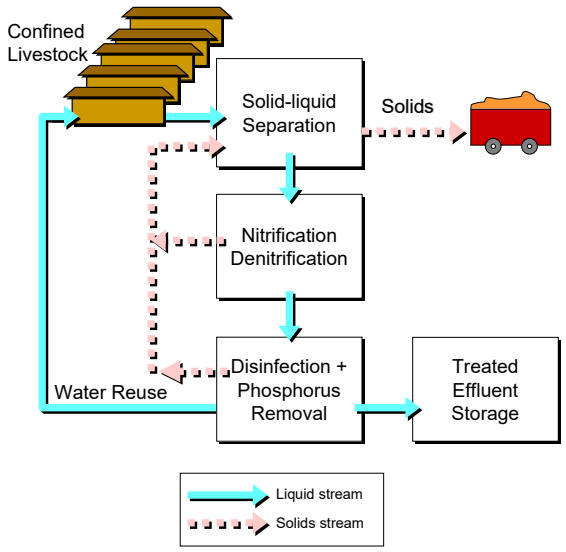

Figure 2. Schematic of the second-generation treatment technology.

The first-generation technology was demonstrated full-scale on Goshen Ridge farm, a 4,400-head finishing farm in Duplin County, NC (Vanotti et al., 2007). The on-farm technology met the environmental performance criteria of an EST (Williams, 2006). It was determined as an unconditional EST for new farms which are permitted and constructed for the first time after March 2005 and for expansion of existing swine farms (Williams, 2006). Recommendations were also made to evaluate an improved, redesigned second-generation version of the wastewater treatment system. The new system design is based on experiences gained during first-generation demonstration and incorporates new science (Vanotti et al., 2010). Changes were intended to significantly

lower capital, maintenance, and operating costs and also to improve system reliability and simplicity. Detailed description of the components and performance of the new system is provided in Vanotti et al. (2009) and Vanotti and Szogi (2007). It was installed at full-scale on B&B Tyndall farm, a 5,145-head finishing farm near Clinton, Sampson Co., NC, and evaluated during 2006-2008 intensively under steady-state conditions.

System Performance – Water Quality Improvement

The wastewater treatment performance data obtained during full-scale operation are summarized in Table 1 showing the values of various water quality indicators as the liquid passed through each treatment module in the Terra Blue system and the overall efficiency of concentration reduction for these parameters. In cleaning up manure wastewater, the system removed 99.99 percent of pathogens, 99 percent of odor-causing components, 95 percent of total phosphorus, 97 percent of ammonia, and more than 99 percent of heavy metals, copper, and zinc. These high removal efficiencies significantly reduced the environmental footprint of the operation. For this reason, in 2010 the farmer was permitted to expand its operation from 5,145 to 11,025 pigs.

Table 1. Wastewater treatment plant performance and system efficiency at Tyndall farm, North Carolina. Data are mean for 107 sampling dates during three pig growth cycles (Dec. 9, 2006 – Feb. 29, 2008) (Vanotti et al., 2009).

Water Quality Parameter	Raw Flushed Manure	After Solids Separation Treatment	After Biological N Treatment	After Phosphorus Treatment	System Efficiency (%)
TSS (mg/L)	11,113	858	147	144	98.3
BOD_5 (mg/L)	6,820	3,032	52	38	99.4
TKN (mg/L)	2,007	1,414	121	83	95.9
NH_4-N (mg/L)	1,251	1,190	103	43	96.6
TP (mg/L)	494	170	85	35	92.9
Cu (mg/L)	16.0	2.01	0.17	0.13	99.2
Zn (mg/L)	24.2	2.91	0.36	0.26	98.9
Odor Compounds (ppb) [a]	71,269	63,642	40	44	99.9
Fecal	4.11	3.47	0.84	0.17	99.99

Coliforms (log cfu/mL)					

[a] Odor compounds = phenol, p-cresol, p-ethylphenol, indole, and skatole.

Animal Productivity and Health Improvement

The reuse of cleaner, sanitized water to refill barn pits reduced ammonia concentration in the air and improved the growing environment. As shown in Figure 2, the treated water was reused on the farm to flush the pits under the barns. It replaced the dirtier lagoon liquid charged with ammonia used for the same task under the traditional lagoon management. Since the recycled wastewater was mostly ammonia free, ambient ammonia levels in the barns dropped an average of 75 percent. As a result, animal health and productivity were enhanced (Table 2). Daily weight gain increased 6.1 percent, and feed conversion improved 5.1 percent. Animal mortality decreased 47 percent, and cull weight was reduced 80 percent (Table 2). The farmer sold an average of 5,265 pigs per growing cycle, which resulted in a 1,138,247-pound net gain per cycle. Using the second-generation Terra Blue system instead of the lagoon system, the farmer sold 61,996 pounds more hogs—a 5.8 percent increase—per growing cycle. Results obtained in this demonstration project are consistent with the observations of Barker (1996) on the substantial animal production advantages that can be realized by improvements in manure management in swine production buildings.

Table 2. Improvement of animal productivity and health indicators obtained with the new waste treatment system compared with the previous lagoon system at the same farm. Data are means of production records obtained in seven barns during five production cycles before conversion and five production cycles after conversion.

	Five growing cycles using the old lagoon system	Five growing cycles with new Terra Blue treatment system	% Change[a]
	Dec. 2004-Dec. 2006	Dec. 2006 – Dec. 2008	
Mortality (%)	5.23	2.77	-47%
Daily Gain (lb/pig/day)	1.48	1.57	+6.1%
Feed Conversion (lb feed/lb meat produced)	2.56	2.43	-5.1%
Cull/cycle [b] (lb)	23,575	4,777	-80%

Gain/cycle (lb)	1,076,251	1,138,247	5.8%

[a] % Change compares the performance obtained with the new system with performance obtained using the preceding lagoon system.
[d] Entire hogs that did not pass inspection.

Mitigation of GHG emissions using Terra Blue aerobic treatment

In addition to the strict environmental standards that EST's need to comply with (i.e. the elimination of pathogens, ammonia emissions, odor, heavy metals, phosphorus, discharge to surface and groundwater, etc.), they can also be very effective reducing GHG emissions (both methane and N_2O), even more than anaerobic digesters per-se. Using protocols adopted though the United Nations Framework Convention on Climate Change (UNFCCC), Vanotti et al. (2008) estimated a 96.9% reduction in GHG emissions by replacement of the traditional lagoon-spray field technology (LST) with the cleaner, aerobic Terra Blue technology. The new system was discussed in a chapter of "Manufacturing Climate Solutions: Carbon-Reducing Technologies and U.S. Jobs," published in 2008 by Duke University (Gereffi et al., 2008). The report was commissioned by the AFL-CIO and the Environmental Defense Fund and featured technologies that could help reduce greenhouse gas emissions and create green jobs in the United States.

Conclusion

We evaluated the effects of improved manure management on air and water quality and animal productivity and health. The treatment system substantially removed N, P, copper, zinc, odor and pathogens. Ammonia concentration in air of the barns was reduced, and animal health and productivity were enhanced: mortality decreased 47%, daily weight gain increased 6.1%, and feed conversion improved 5.1% compared to the traditional lagoon management. These results overall showed that cleaner alternative technologies can have significant positive impacts on livestock production and the environment. In 2007, the State of North Carolina started a statewide Lagoon Conversion Program (LCP) that provided financial support to livestock farmers who installed new manure management technologies that improved water quality and air quality.

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