CHAPTER 5

Super Soil Systems

A New Solution for Managing Hog Wastes

by

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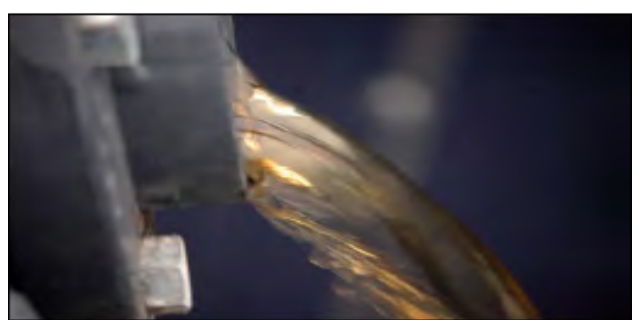
Summary
Over the past two decades the U.S. swine industry has evolved from small, traditional farms to large, industrial farms in which thousands of swine are confined in intensive feeding conditions. These large, specialized operations create great quantities of highly concentrated hog wastes. The dominant method of handling these wastes is to keep them in open lagoons and to spray them onto nearby fields, which, particularly in case of heavy rains, can contaminate surface water and groundwater. Air pollutants from industrial hog farms cause odors and contribute to health risks. Perhaps less well known is the swine industry's contribution to greenhouse gas emissions. When these emissions are calculated to include deforestation for feed crops, the global livestock sector, including swine production, is estimated to cause 18% of global greenhouse gas emissions measured in CO_2 equivalent. This is an even higher share than transport.

North Carolina, the nation's second largest hog producer, has made significant strides toward a viable alternative to open waste lagoons. The state's Lagoon Conversion Program has provided support for a particularly promising new technology, Super Soil Systems. This technology has met all the state's environmental performance standards, treating the entire waste stream from the farm. Super Soil also reduced greenhouse gas emissions by a remarkable 97%.

Super Soil is not yet commercially available, yet it is an example of a technology that could potentially be widely adopted. The adoption of this or similar technologies would involve manufacturing jobs producing large tanks—ranging, in the demonstration facility, from 11 feet to 36 feet in diameter—and pipes, which total some 2,000 feet. Additional manufacturing jobs would be needed to make the equipment, along with the associated requirements for steel, glass, concrete, and other materials, and construction jobs to build the facility. By addressing critical environmental problems caused by large animal farms, Super Soil and related technologies could help hog-producing states protect existing jobs and keep the door open to future job expansion. This dynamic is evident in North Carolina, where finding an alternative to open hog waste lagoons serves the best interest of many closely affiliated jobs in the meat processing industry. Because Super Soil technology is also applicable to large beef operations, it is an opportunity for the United States to become a world leader in solving serious environmental problems associated with livestock farming, problems that will only become more acute as the demand for meat steadily rises among consumers in developing countries.

Figure 5-1. On-Farm Super Soil System

Source: Vanotti & Szogi, 2007



Source: Vanotti & Szogi, 2007

Introduction

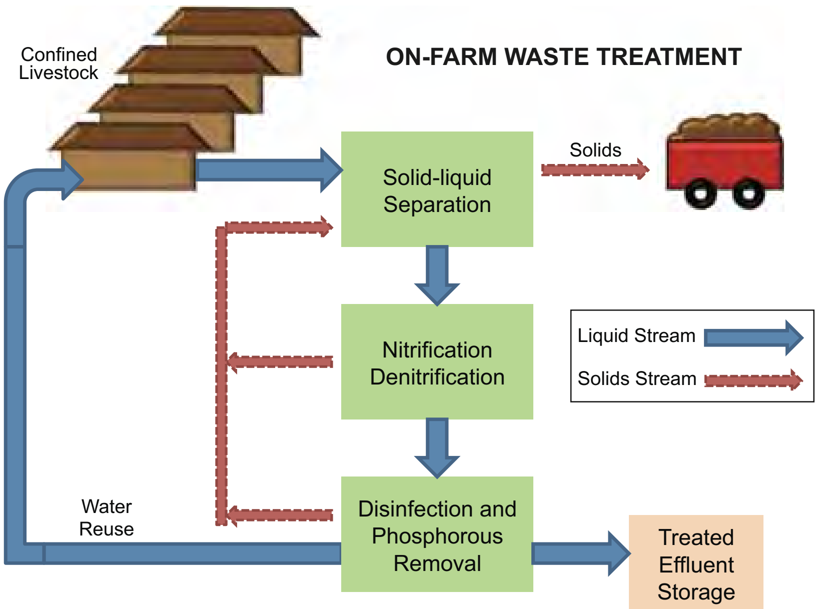
The United States is leading the international trend toward consolidation of animal farming into extremely large, integrated industrial operations (Key & McBride, 2007). These large, specialized operations create great quantities of highly concentrated hog feces and urine. Federal and state regulations allow hog farms to keep these wastes in open lagoons and to spray them onto nearby fields; however, both of these methods pose several environmental problems. The lagoon pits sometimes rupture after heavy rains, and this runoff, along with that from the fields on which waste is sprayed, can contaminate surface water and groundwater. Air pollutants from industrial hog farms cause odors and contribute to fine particulate matter, diminishing quality of life and increasing health risks for nearby residents (Wing et al., 2008).

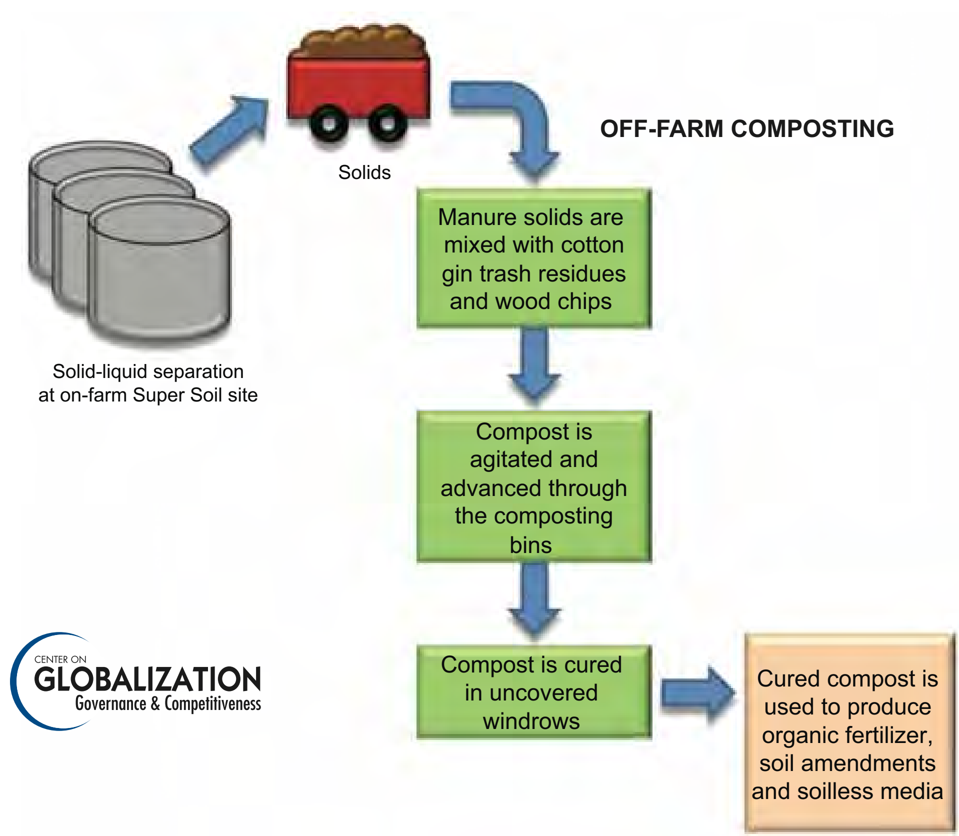
The swine industry also generates significant greenhouse gas emissions. The three major greenhouse gases are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Agriculture is responsible for roughly 30% of total U.S. methane emissions, and manure management accounts for about 25% of methane released by the agricultural sector. Manure management is also responsible for some 5% of all U.S. nitrous oxide emissions. These emissions are particularly significant because they are potent heat-trapping gases. On a per-molecule basis, methane and nitrous oxide have 21 times and 270 times the global warming potential of CO_2, respectively (U.S. EPA, 2006). When emissions are calculated to include deforestation for feed crops, the global livestock sector including swine production is estimated to be responsible for 18% of greenhouse gas emissions measured in CO_2 equivalent—an even higher share than transport (Gerber et al., 2007).

North Carolina, the nation's second largest hog producer, has undertaken substantial measures to deal with the growing hog waste problem. The state has more than 10 million hogs, 97% of which are on farms with 2,000 or more head (USDA, 2008). In 1997, responding to environmental concerns, the state government placed a 10-year moratorium on new and expanded swine operations. When this moratorium expired in 2007, it was replaced by a permanent ban on new lagoons and spraying fields, along with a Lagoon Conversion Program that offers grants to help farmers pay for adopting alternatives to waste lagoons (Rawlins, 2007).

A particularly promising new alternative that has received support from North Carolina's Lagoon Conversion Program is called Super Soil System. This technology was thoroughly evaluated in conjunction with an agreement between the state's Attorney General and Smithfield Foods, the world's largest hog producer and pork processor. Under the Smithfield Agreement, 18 different hog waste technologies were tested against five environmental performance standards. Those standards included the substantial elimination of ammonia emissions, odor, pathogens, soil contamination by nutrients and heavy metals, and elimination of hog waste discharge and runoff. Only five technologies met all the standards. Of all technologies tested, only one, Super Soil Systems, treated the entire waste stream from the farm. Super Soil not only met all of the performance criteria, it also reduced greenhouse gas emissions by 97% (Vanotti et al., 2007).

Figure 5-2. Super Soil Waste Treatment Process





Sources: On-farm process adapted from figure in Vanotti & Szogi, 2007; off-farm process based on description in Vanotti, 2005.

The second generation Super Soil System is made up of two elements: a liquid treatment system consisting of a series of large steel tanks located at the hog farm, and a solids processing facility, which is located offsite (see Figure 5-2). Liquid treatment involves separating the solids out of the hog waste stream. The solids are then transported to an offsite location where, in a proprietary process, they are composted and blended with other materials to make a value-added product, commercial fertilizer (Vanotti & Szogi, 2007).

In addition to Super Soil, several technologies offer promise for handling hog waste in different combinations that best meet the needs of a particular farm. Methane capture is one such technology. When animal wastes are kept in a digester or anaerobic lagoon, the decomposition process produces "off-gases," which consist of about 70% methane. This methane can either be simply flared off, which converts methane to CO_2, or it can be fed into a combustion device to generate electricity, thus providing a renewable energy alternative to coal-based electric generation. These systems, also called biogas digesters, have been used extensively in small-scale settings in developing countries and are also feasible on a much larger scale. For example, one of the technologies tested along with Super Soil Systems in North Carolina was a methane digester in use on a 4,000 head sow farm.[6] Approximately 100 digesters are operational or under construction on farms across the United States; however, this represents merely 1% of the 7,000 candidate dairy and hog farms (Resource Strategies, Inc., 2006). While anaerobic digesters provide some air quality benefits (methane capture and odor reduction), they can only provide sufficient water quality benefits to meet environmental performance standards if combined with technologies that treat the digester effluent or other liquids left on the farm.

Several possible combinations of collectors, tanks, digesters, and mixing areas could make up a methane recovery system. When implemented on a large scale, these systems may use large tanks and piping similar to those that make up the Super Soil System. Thus, although the analysis that follows will focus specifically on Super Soil technology, portions of the analysis are potentially relevant to the materials and components required for both systems.

Super Soil System Value Chain

Super Soil technology will soon be operating on the equivalent of six North Carolina farms with the potential to treat 70,000 hogs (Rudek, 2008), but since it is still under development, its value chain looks quite different from those of established industries. For this report we have divided the Super Soil System value chain into four segments: materials, components, design, and end use (see Figure 5-3). The left side of the value chain, including materials and components, applies to the equipment that makes up the second generation demonstration facility in eastern North Carolina. The design segment describes the two generations of Super Soil technology that have been developed to date, and the company's future plans for a third generation. The end use segment highlights the potential for implementing the technology on large hog farms across the United States, as well as for managing other wastes from large animal operations, such as cattle manure.

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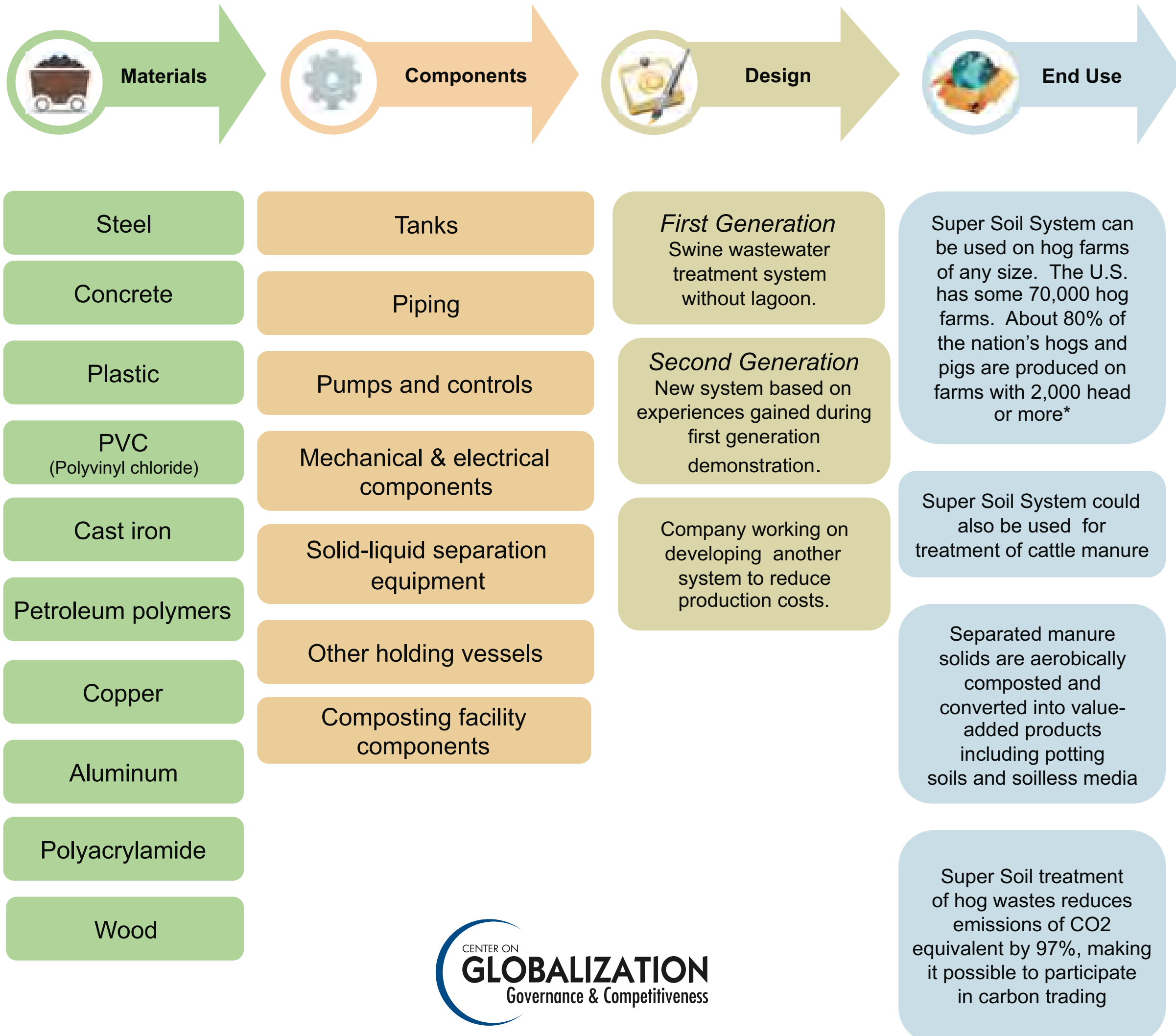
[6] Sows live to reach a weight roughly three times that of "finishing" pigs—which are typically slaughtered by the age of six months—and so they produce a greater amount of waste. A 4,000 head sow farm produces wastes equivalent to a 12,800 head finishing farm (Rudek, 2008).

Figure 5-3. Super Soil Systems, Simplified Value Chain



*Key & McBride, 2007
Source: CGGC, based on interviews and Vanotti & Szogi 2007.

The main material in the current demonstration facility, the second generation Super Soil, is steel, which is used for a series of large tanks and other holding vessels. A major focus of an upcoming third generation project, now in the design stage, is to reduce installation costs, and alternatives to steel will be an important possibility. The third generation system will be implemented at several sites in North Carolina and, while emphasizing reduced costs for materials, will use largely the same components. One option under consideration is to build the treatment infrastructure, including tanks, with concrete or glass-lined steel (Campbell, 2008).

Installation costs of Super Soil technology are higher than those for the anaerobic waste lagoons now widely used in the swine industry, although there are at least two ways in which these costs can be partly offset. First, the solids are separated out of the waste stream and composted into a value-added soil "container mix," which can be sold in bulk to nurseries and large retail outlets such as Lowe's or Home Depot. Second, the considerable reductions in greenhouse gas emissions could bring value under a carbon trading system, in which farmers earn money based on the amount of carbon-dioxide equivalent they prevent from entering the atmosphere.

According to a report by USDA researcher Matias Vanotti and colleagues, replacing the traditional hog lagoon with this cleaner, aerobic waste treatment technology nearly eliminated greenhouse gas emissions; in a 4,360-head swine operation, the new lagoon process reduced total greenhouse gas emissions 97%, from 4,972 tons of carbon dioxide equivalent to 153 tons of CO_2 equivalent per year. Including the entire Super Soil process, the project reduced greenhouse gas emissions by 1.1 tons of CO_2-equivalent per hog per year (Vanotti et al., 2007). According to an analysis of Super Soil using Chicago Climate Exchange trading values of $4 per ton of CO_2, the return to the hog farmer was $1.80 per finished pig (Vanotti et al., 2007).

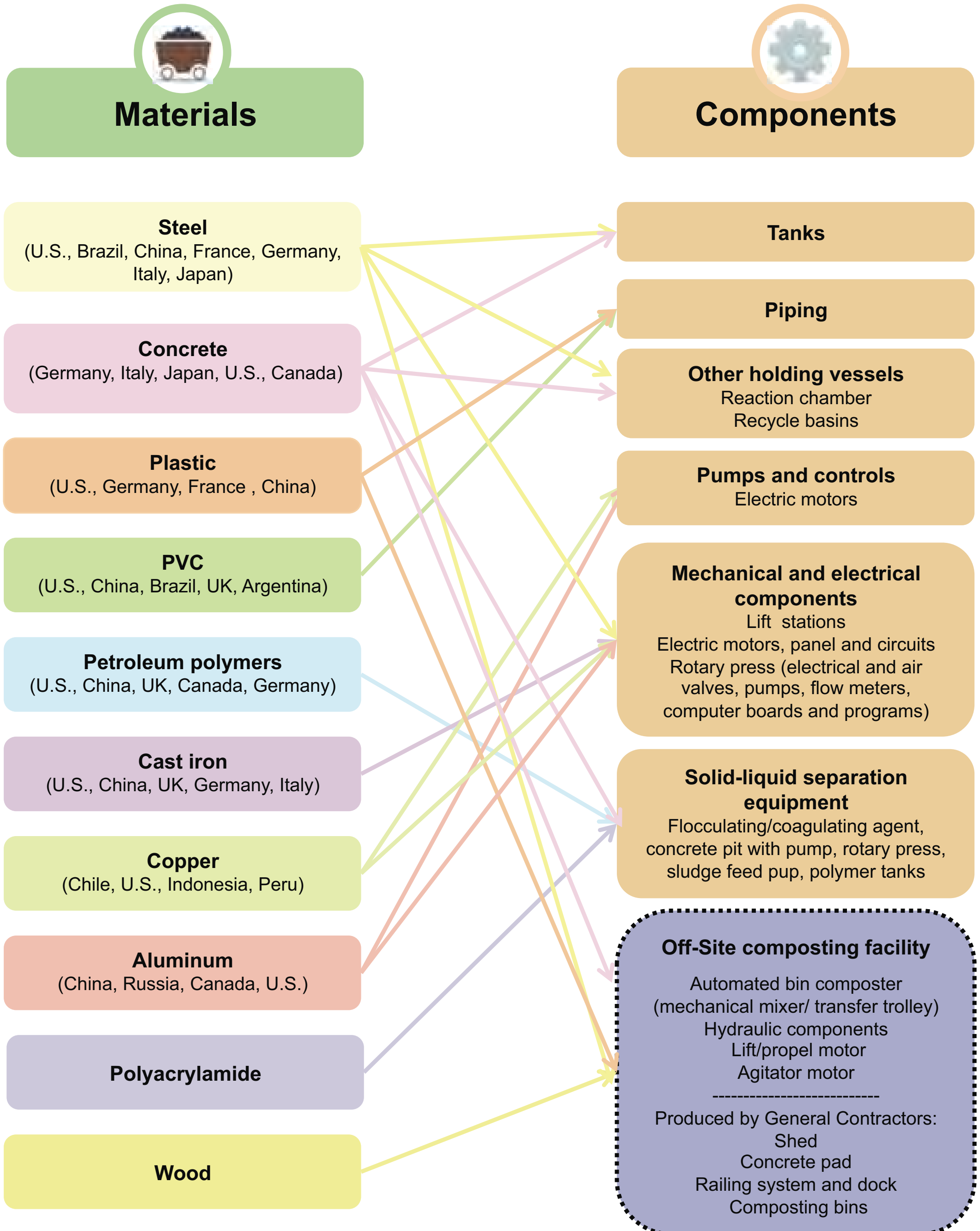
The on-farm system also removed more than 97% of suspended solids from wastewater. It eliminated 95% of total phosphorous, 99% of ammonia, 98% of copper, and more than 99% of biochemical oxygen demand and odor-causing components, producing a disinfected effluent. In addition, the old wastewater lagoon at the demonstration site became clean and aerated, with substantially lower ammonia emissions (Vanotti et al., 2007).

Materials and Components

The main materials used in the Super Soil System are steel, concrete, and polyvinyl chloride (PVC). The system's tanks and other holding vessels use large amounts of steel, including stainless steel, epoxy-coated steel, glass-lined steel and galvanized steel. Of the seven tanks in the system, two consist of epoxy-coated steel, and five consist of glass-lined steel. These tanks and other vessels range in size from 11 feet to 36 feet in diameter, and all have concrete bases. The system uses approximately 2,000 feet of piping, which can be made of steel, PVC or other plastic. Other materials include cast iron, copper, aluminum, polyacrylamide (a flocculating/ coagulating agent), and petroleum polymers. The United States is one of the leading producers of all the major materials used in the system (see Figure 5-4).

The components that make up the on-farm Super Soil System (where solids are removed and the liquid wastes are treated) can be grouped into six main categories: tanks; piping; pumps and controls; mechanical and electrical components; solid-liquid separation equipment; and other holding vessels (see Table 5-1). Steel tanks are the largest component. Mechanical and electrical components include lift stations, electric motors, panels and circuits, and a rotary press. The solid-liquid separation process includes a rotary press; sludge feed pump; polymer tanks; a concrete pit with a pump; and a flocculating agent.

Figure 5-4. Super Soil Components and Major Materials with Top Producing Countries



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Source: CGGC, based on OneSource industry market research, individual interviews, company websites, Vanotti and Szogi 2007, and Vanotti 2005.

The offsite Super Soil composting facility treats solids using an in-vessel composting method (one of many suitable methods for composting animal manure). With in-vessel composting, the material to be composted is confined within a building, vessel, or container, and the composting process is accelerated via forced aeration and mechanical turning of the materials. The Super Soil composting facility on the Hickory Grove Farm in Sampson County, North Carolina, first mixes the manure solids with cotton gin trash residues and wood chips, then agitates the material and advances it through composting bins in an enclosed shed. The main components in this composting facility are an automated bin composter (mechanical mixer), which moves over the composting bins on a railing system, and a dock. The mixer uses hydraulic components as well as propel motors and agitator motors. The main materials used for the construction and installation of the automated machinery in the composting facility are steel and concrete. The shed enclosure is constructed from wood, plastic, and standard roofing material.

Table 5-1. Description of Major Super Soil System Components

Category	Subcomponent	Picture
Tanks	Aeration tank	
	Clean water tank	
	De-nitrification tank	
	Homogenization tank	
	Large settling tank	
	Nitrification tank	
	Phosphorous removal tank	
	Phosphorous removal tank	
	Polymer preparation tank	
	Scum tank	
	Storage tank	Source: Vanotti & Szogi, 2007
Piping	Diffuser piping network Piping throughout entire system Various materials possible	
Solid-Liquid Separation Equipment	Polyacrylamide	
	Concrete pit with one pump for lifting	
	Rotary press separator	
	Polymer preparation tanks	
	Polymer metering tank	
	Sludge feed pump	
	Dual, 48” rotary press	Source: Vanotti & Szogi, 2007

Category	Subcomponent	Picture
Mechanical and Electrical Components	Submergible mixer	
	Lift stations	
	Electric motors, panel and circuits	
	Rotary press (electrical and air valves, pumps, flow meters, computer boards and programs, electrical parts)	
Pumps and Controls	Concrete pit with one pump for lifting	
	Polymer metering pump	
	Sludge feed pump	
	250gpm capacity pump	
	Lime injection pump	
Other Holding Vessels	Recycle basins	
	.3 m^3 reaction chamber	
Trickle Irrigation System	Note: This is an optional feature. Excess water can also be applied using an overhead irrigation system.	
Automated Composting System	Mechanical mixer/ transfer trolley	 Source: Vanotti, 2005
	Railing system and dock	
	Composting bins	
	Lift/propel motor	
	Agitator motor	
	Hydraulic components	
	Concrete pad	
	Shed	
	Front end loader (tractor with shovel)	

Source: CGGC, based on company websites, Vanotti and Szogi 2007, and Vanotti 2005.

Selected Component Suppliers

The types of firms associated with the major components in Super Soil Systems include those that supply tanks, pumps, piping, mixers, and controls to wastewater treatment and irrigation systems. For proprietary reasons, names are not available for the companies that provided the actual components used in the Super Soil demonstration facility in Clinton, North Carolina. However, a list of representative companies in the relevant component categories is found in Table 5-2.

Widespread adoption of Super Soil System technology would involve manufacturing jobs producing large tanks—ranging, in the demonstration facility, from 11 feet to 36 feet in diameter—and pipes, which totaled some 2,000 feet. Additional manufacturing jobs would be needed to produce the other components listed in detail above, along with the associated requirements for steel, glass, concrete, and other materials. Construction jobs would be involved in building the facility, including large equipment, housings, and freestanding structures. Installation jobs would be associated with the piping, with steel pipes necessitating skilled labor, and PVC and other plastics requiring less specific labor skills. Although the operation of the system is fully automated, some labor would be required to perform maintenance and part replacement. Certain components of Super Soil equipment, including mixers, pumps, and blowers, have a limited life span, and replacement can be expected after 10 years of operation (Rudek & Shao, 2007).

Super Soil and related technologies could help hog-producing states protect existing jobs and keep the door open to future job expansion. By addressing critical environmental problems caused by large animal farms, these technologies serve the best interest of a large number of closely associated jobs in the meat processing industry. This dynamic is evident in North Carolina, home of the world's largest pork processing facility, where the state government has combined environmental laws with support for innovation in the development of Super Soil and other hog waste solutions.

Table 5-2. Component Manufacturing Companies Relevant to Super Soil Technology*

Component	Company Name	Location	Total Sales (USD mil)	Total Employees
Coated Steel and Stainless Steel Tanks	Fisher Tank Company	Lexington, SC	$34.0	45
	Columbian-TecTank	Parsons, KS	$32.8	140
	Baker Tanks, Inc. (BakerCorp)	Seal Beach, CA	$28.5	400
	Pittsburgh Tank Corporation	Monongahela, PA	$28.5	50
	Highland Tank & Manufacturing Company	Stoystown, PA	$25.0	160
	Western Tank and Lining Ltd.	Canada	$24.4	27
Ductile Iron, Copper and Metal Pipes; Plastic and FRP Pipes	Ameron International	Pasadena, CA	$631.0	2,600
	Future Pipe Industries	United Arab Emirates	$556.4	3,500
	Reinforced Plastic Systems Inc.	Canada	$208.0	150
	Oxford Plastics, Inc.	Canada	$41.4	30
Coagulants, Flocculants and Precipitants	SNF Floerger SAS	France	World's top producer	n/a
	Ciba Specialty Chemicals Holding Inc.	Switzerland	$5,211.8	14,130
	HaloSource, Inc.	Bothell, WA	$76.2	80
	Kemira Water Solutions, Inc.	Lakeland, FL	$41.4	200
	Bentonite Performance Minerals	Lovell, WY	$20.9	70
Pumps, Motors, Pumps and Controls, Pump Drivers	Rockwell Automation, Inc.	Milwaukee, WI	$5,003.9	20,000
	Kavlico Corporation	Moorpark, CA	$156.1	1,400
	Weir Pumps Ltd.	Salt Lake City, UT	$54.4	800
	Armstrong Pumps, Inc.	North Tonawanda, NY	$33.7	110

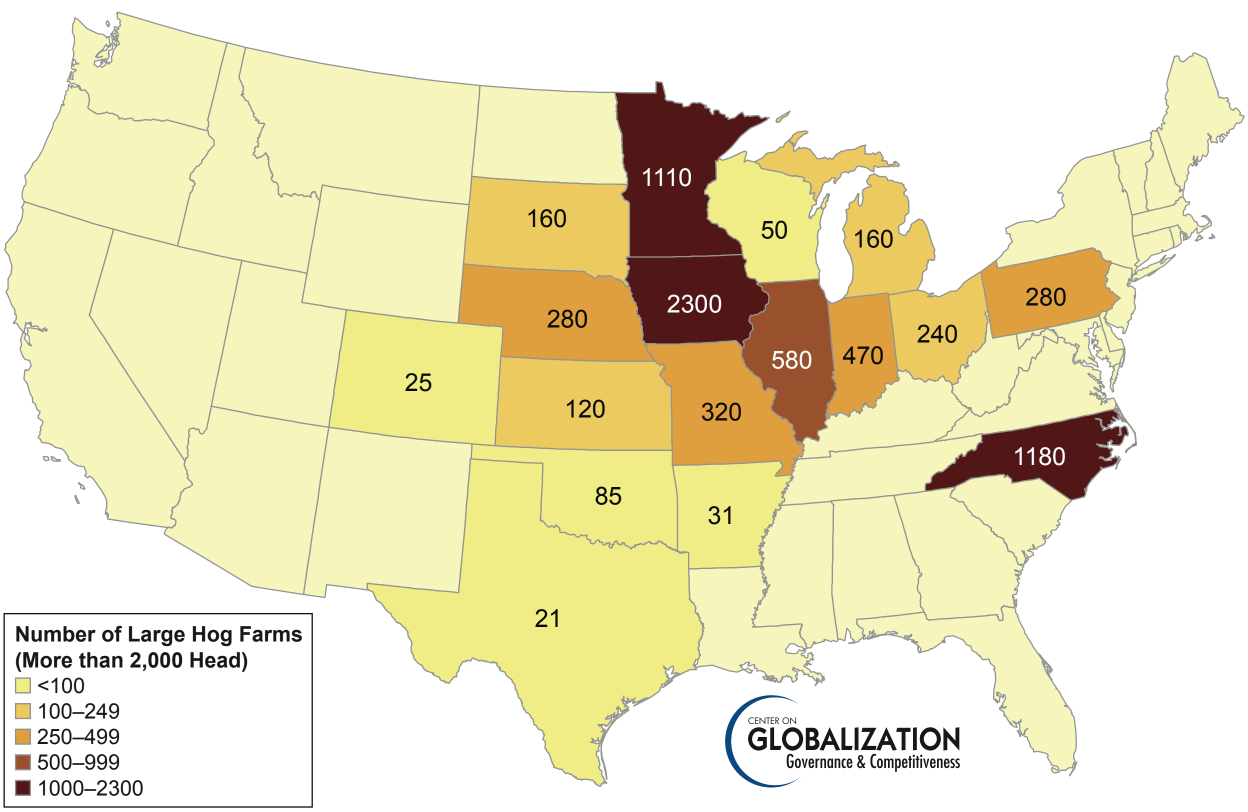
Component	Company Name	Location	Total Sales (USD mil)	Total Employees
Lift Stations and Vertical Pumps	Sulzer Pumps Ltd.	Switzerland	$2,296.8	10,000
	Gorman-Rupp Company	Mansfield, OH	$305.6	1,065
	Topp Industries, Inc.	Rochester, IN	$29.3	125
	Holland Pump	Brunswick, GA	$9.2	30
In-Vessel Automated Composter Systems	Farmer Automatic of America	Rochester, IN	$4.2	10
	Engineered Compost Systems	Seattle, WA	$3.1	17
	Green Mountain Technologies, Inc.	Whittingham, VT	n/a	n/a

*With the exception of Farmer Automatic of America, this list refers to relevant companies, not actual suppliers to Super Soil Systems
Source: CGGC, based on company websites and industry sources.

Markets

The United States accounts for 10% of global pork production, making it the world's third largest pork producer, behind China (46%) and the European Union (24%) (USDA, 2008). The U.S. swine industry is dominated by large farms; some 80% of the nation's hogs and pigs are produced on farms with 2,000 head or more (see Figure 5-5).

Figure 5-5. Number of Large Hog Farms, by State, 2007



Source: CGGC, based on USDA/NASS 2008

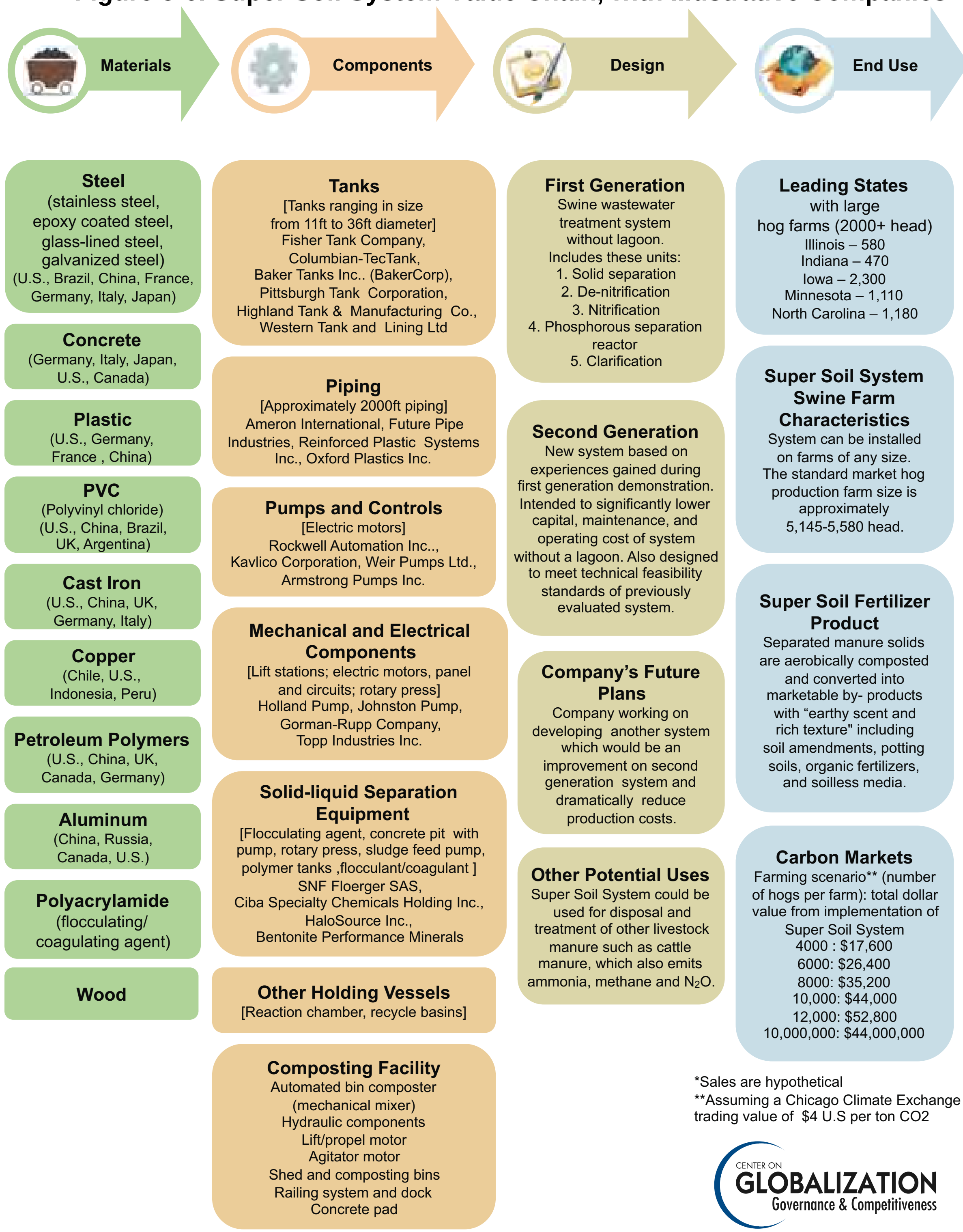
Nationwide, more than 7,700 farms fall in this size category. Farms of this size are the most likely to receive pressure from citizens and governments to mitigate the environmental impacts of hog farming operations. Environmental groups are stepping up the pressure on governments to regulate factory farms to clean up their waste as other industries are required to do. The Sierra Club, for instance, is targeting factory farms as one of its national priority campaigns (Sierra Club, 2008). In 2007 the organization joined a local Iowa group, Iowa Citizens for Community Improvement, and the Washington, D.C.-based Environmental Integrity Project, in filing a formal legal petition urging the U.S. EPA to strip the Iowa Department of Natural Resources of its authority to issue factory farm operating permits to the state's growing number of concentrated animal feeding operations, because of continuing violations of the Clean Water Act (Environmental Integrity Project, 2007). Since open pit lagoons are the main focus of these efforts, a proven technology such as Super Soil Systems would likely have a large potential market as an environmental solution—one that could help states avoid having to take more drastic measures, such as banning new and expanded hog operations.

Conclusion

Animal farming is marked by a growing international trend toward consolidation into exceptionally large operations, which pose serious environmental hazards, including greenhouse gas emissions and pollution of rivers, lakes, and streams. Super Soil Systems are one promising alternative to the dominant method of handling hog wastes: storing them in open lagoons. Super Soil fully treats all liquid and solid wastes from the hog farm, nearly eliminating greenhouse gas emissions and passing all environmental performance standards in North Carolina, the state with the nation's strictest environmental restrictions for hog farms.

As the hog industry grows in other states, state governments will likely need to follow North Carolina's lead and require effective waste management, which means providing an alternative to open lagoons. Replacing existing lagoons and building new systems such as Super Soil would create U.S. manufacturing jobs in large tanks and piping, other wastewater treatment equipment, and in construction and installation. Because the technology is also applicable to large beef operations, it is an opportunity for the United States to become a world leader in solving serious environmental problems associated with animal factory farming, problems that will only become more acute as the demand for meat steadily rises among consumers in developing countries.

Figure 5-6. Super Soil System Value Chain, with Illustrative Companies



Source: CGGC, based on Campbell, 2008; Rudek, 2008; Vanotti, 2005; Vanotti & Szogi,2007; and Vanotti et al., 2007.

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