FEASIBILITY STUDY

Waste Management Technologies

Used in the Swine Industry

Pork Checkoff at Work.™

National Pork Producers Council
P.O. Box 10383
Des Moines, Iowa 50306 USA
(515) 223-2600
FAX (515) 223-2646
www.nppc.org

March 7, 2000

Dennis Burke
Cyclus Envirosystems, Inc.
6007 Hill Road NE
Olympia, QA 98516-9551

Dear Mr. Burke:

Enclosed you will find a copy of the Feasibility Studies that were completed last year by Cavanaugh & Associates. You can also access the reports on our website. The web address is: www.nppc.org/PROD/OSI/cavanaugh/

It is our hope that these reports will be of benefit to our producers.

Sincerely,

Linda Aycock
Research Program Manager

Introduction

At the 1997 World Pork Expo, National Pork Producers Council announced a new initiative that would try to find producer friendly solutions to odor from hog manure. The initiative would be funded with checkoff dollars. The Odor Solutions Initiative (OSI) Committee was formed to solicit and evaluate biological, chemical, mechanical, nutritional and management technologies that would abate or eliminate odor. The OSI Committee is chaired by John Kellogg, Illinois producer; and is a mix of producers and scientists.

Several hundred companies were given the opportunity to submit a proposal to have NPPC evaluate their technologies in April 1998. The OSI Committee reviewed all proposals and determined that several warranted further evaluation using additional criteria. Thus, in the spring of 1999, National Pork Producers Council contracted with Cavanaugh & Associates, P.A. - Consulting Engineers of Winston - Salem, North Carolina to provide a technical and economic analysis (also referred to as a feasibility study) of several proposals selected by OSI. Proposals in the manure pit additive category will be evaluated in a column test program at Purdue University. The pit additive proposals did not go through the Cavanaugh evaluation process.

Each report, or Proposal Evaluation Summary, consists of a Technology Evaluation Narrative, a Technical Analysis, Site Specific Data (Daily Basis), and an Economic Analysis. Of great benefit to the producer is the cost per pig for each technology (found in the Economic Analysis portion).

In an effort to find common ground for evaluating the proposals, Cavanaugh & Associates developed a set of assumptions to use in preparation of the reports. These assumptions encompass many aspects of hog production, i.e., number of animals, lagoon construction design, and energy costs. The assumptions can be found on page 1.

Each vendor, who had a proposal evaluated by Cavanaugh & Associates, was given the opportunity to make comments about the report. Not all vendors chose to comment, however, these comments can be found at the back of each report. It should be noted that a significant amount of time has lapsed since the OSI Committee first received the proposals until the publication of this book of reports. We realize that costs associated with these proposals may have changed and suggest that vendors be contacted for up-to-date costs associated with the technologies. Vendor information can be found in the Technical Analysis portion.

Table of Contents

National Pork Producers Council
Odor Solutions Initiative

Technology Proposal Evaluations Assumptions

Preface: Comparative analysis of a broad spectrum of technologies, techniques and process equipment operating in such a diverse environment as the swine industry is a challenging undertaking. Many factors complicate the process: discrete growth staging, geographical & climatological considerations, farm size & layout, barn size, barn type, regional design & treatment preferences, growing techniques and composite growth stage farms combine to make analysis difficult. Some generalizations were necessary to keep the evaluation procedure manageable and stay within the scope of the project, but every effort was made to ensure that any data used was correlated against accepted standards from industry, government and academia. Other assumptions are as follows:

- Waste characteristics, generation rates and lagoon design & management is based on works by Barker, et al (North Carolina State Univ.), Jones (Purdue Univ.), Fulhage (Univ. of Missouri), Huhnke (Okla. State), Nicolai (Univ. of Minn.) and publications from the U.S. Dept. of Agriculture and the American Society of Agricultural Engineers.
- Animal population data is based on 2.2 farrowing cycles per year and 2.8 finishing cycles per year. Total number of animals per year (at farrowing facilities) is based on a litter average of 9 piglets.
- Two growth scenarios were allowed: farrow-to-feeder and feeder-to-finish. Proposals utilizing a different scenario were adjusted, based on waste generation rates and population, to an equivalent population in the closest category.
- Lagoon construction was based on standards that are currently being developed under the auspices of NRCS for the EPA. Design basis is 180 days storage and 25 year, 24 hour storm (min.) assimilation with 2' of freeboard. The lagoons are lined with synthetic geomembranes, side slopes are 2:1 and aspect ratios are 2:1. Average water depth is 10' with a 3' freeboard. Construction costs, nationwide, average $2.60/cubic yard for earthwork and $1.20/square foot for liners. Lagoon data was provided for comparative purposes, primarily.
- Energy rates are based on $0.10/kwhr; any proposal which departed drastically from this value in its operating cost projection was adjusted accordingly.
- Capital costs and operating costs were derived from proposal provided data. They do not reflect the total grant request but, rather, what a grower could expect to pay.

Good and accepted engineering practices and judgement were applied in every instance.

National Pork Producers Council
Odor Solutions Initiative

Proposal Evaluation Summary

NPPC Reference Number: 16
Cyclus Envirosystems, Inc.

May, 1999

Analysis and Technical Review Prepared By:
Cavanaugh & Associates, P.A. - Consulting Engineers
Winston - Salem, North Carolina

Technology Evaluation Narrative #16

Synopsis

The AGF Technology uses proprietary processes (dissolved methane gas flotation) to promote anaerobic stabilization at a unusually high rate with short retention times. The waste stream is then treated further to remove solids and a special unit removes essentially all the phosphorus and ammonia (struvite) in crystalline or pellet form fertilizer.

Science Basis

Anaerobic digestion is the most efficient stabilization process from an energy standpoint, and is a net energy producer, however, a large portion of phosphorus and nitrogen is lost, along with much organic matter and anaerobic bacteria. By concentrating, conserving and returning the biomass (bacteria) to the primary reactor, it is possible to improve the ability of the anaerobic digestion process to rapidly degrade the soluble and volatile constituents of the waste, which would otherwise be lost into the effluent from the reactor. The AGF process accomplishes this by using the available biogas to function similar to Dissolved Air Flotation and thicken and retain the biomass within the digester. This allows hydraulic retention times to be shortened without fear of washing out the viable biomass. Laboratory scale testing has shown that over 76% of influent volatile solids could be converted to methane gas and soluble components at hydraulic retention times of only 10 days, compared to 50% and 20 days in conventional digesters. Development of a pilot operation showed that stabilization could be accomplished in much less time than 5 days; tests performed at a food processing plant where COD levels approached 20,000 mg/l showed that 95% of the waste was converted to gas and soluble products at hydraulic retention times of less than 1 day! This also means that the effective capacity of the digester increases dramatically, or, the same degree of anaerobic stabilization can be achieved with a much smaller digester.

Opinions

The AGF process represents some of the most innovative technology seen by this reviewer to date as a potential solution to the nationwide animal waste issue. Many technologies focus on a very narrow part of the issue, failing to note that they solve one problem while creating another one. This process appears to have anticipated and addressed every facet of the waste treatment problem. One particular aspect is especially impressive--they recognize the value of recovering the nutrients in the most concentrated (and compact) form, struvite, which greatly improves storage, transportation and utilization aspects of nutrient management. The cost of the process is offset by the overall efficiencies obtained and the flexibility of the process design. The process is designed to operate with a minimum of attention (typically, 1.5 hrs./day). It possesses potential, not only as an individual farm solution, but as a collective solution.

National Pork Producers Council - Odor Solutions Initiative
Proposal Evaluation Summary

Cavanaugh & Associates, P.A.

Technical Analysis

NPPC Ref. #: 16

Technology Title:	AGF Technology
Proprietor of Technology:	Cyclus EnviroSystems 6007 Hill Road NE Olympia, Washington 98516 Dennis A. Burke, P.E.
Type of Technology (descriptive):	High Rate Anaerobic Digestion

Biological
Chemical
Physical
Composite

High rate, closed reactor anaerobic digestion with maximized nutrient recovery

Principal & Auxiliary Subcomponents		**Market Available?**	**Operating Elsewhere?**	**Proven Technology? (3 Yr. Period Min.)**	**Pilot Scale Technology?**	**(1 Unit) Capital Cost**	**Annual O&M Cost**
Pumping/Flushing							
Solids Separation		Yes	Yes				
Holding Reservoirs		Yes	Yes				
Chemical Addition		Yes	Yes				
Energy Addition	***						
Aeration							
Biologic		Yes	Yes	Partially	Yes	$ 260,000	$ 38,000
Covers/Baffles		Yes	Yes				
						$ 260,000	$ 38,000
Compliance/Implementability	90%	100%	100%				

Notes:
Degree of categorical compliance is valued on a scale of 0 to 100 with {0} indicating the minimum and {100} indicating the maximum. Category weighting indicates the probability of achieving claimed performance and the period factor for that level of performance. Economic factors for investment and operation/maintenance are likewise assigned. Implementability represents degree of difficulty in applying the technology to new and existing operations.
*** Indicates probability of needing additional subcomponents (or departure from conventional requirements) to achieve purported performance.
Costs do not reflect energy or nutrient recovery.

National Pork Producers Council - Odor Solutions Initiative
Proposal Evaluation Summary

Cavanaugh & Associates, P.A.

Site Specific Data (Daily Basis)

NPPC Ref. #: 16

Farm Type:	No. Of Head	Steady State Live Weight	Solids Volume (Daily)	Liquid Volume (Daily)	Barn Lbs N	Barn Lbs P	Lagoon Lbs N	Lagoon Lbs P
Farrow to Feeder (No. of Sows)	-	-	-	-	-	-	-	-
Feeder to Finish	10,000	1,350,000	7,020	6,480	560.0	220.0	60.0	40.0

Current Technology (For Comparative Purposes)	Volume Required (Cu. Ft.)	Area Required (Sq. Ft.)	Spray Field Required (Ac.)	Lbs O2 Rqmt. (COD/2)	HP Rqmt.	Construction Cost	Energy Cost (Yr)
Anaerobic Lagoon							
(Farrowing)	-		-				
(Finishing)	2,700,000	292,279	160.00			$ 730,260	
Aerobic Lagoon							
(Farrowing)		-		-	-		$ -
(Finishing)	1,060,418	120,000		5,700.0	120.0	$ 323,276	$ 78,420

(Lagoons are lined with geotextiles)

Purported Performance:	Claimed*	Theoretical**	Demonstrated***
BOD/Nutrient Reduction	90%	90%	Yes
Odor Reduction	Yes	Yes	Yes
Growth/Health Improvement	Yes	Yes	
Cost Reduction	Yes	Yes	
Byproduct Generation	Reduced	Reduced	Yes
Byproduct Utilization	Maximized	None	Yes

* Vendor provided performance figures (Blank if no data provided)
** Stoichiometric physical/chemical figures (Calculated-applies to nutrients) or the closest market available technology at equivalent loading/energy inputs.
*** Actual performance demonstrated by the system.

Notes:

National Pork Producers Council - Odor Solutions Initiative
Proposal Evaluation Summary

Cavanaugh & Associates, P.A.

Economic Analysis

NPPC Ref. #: 16

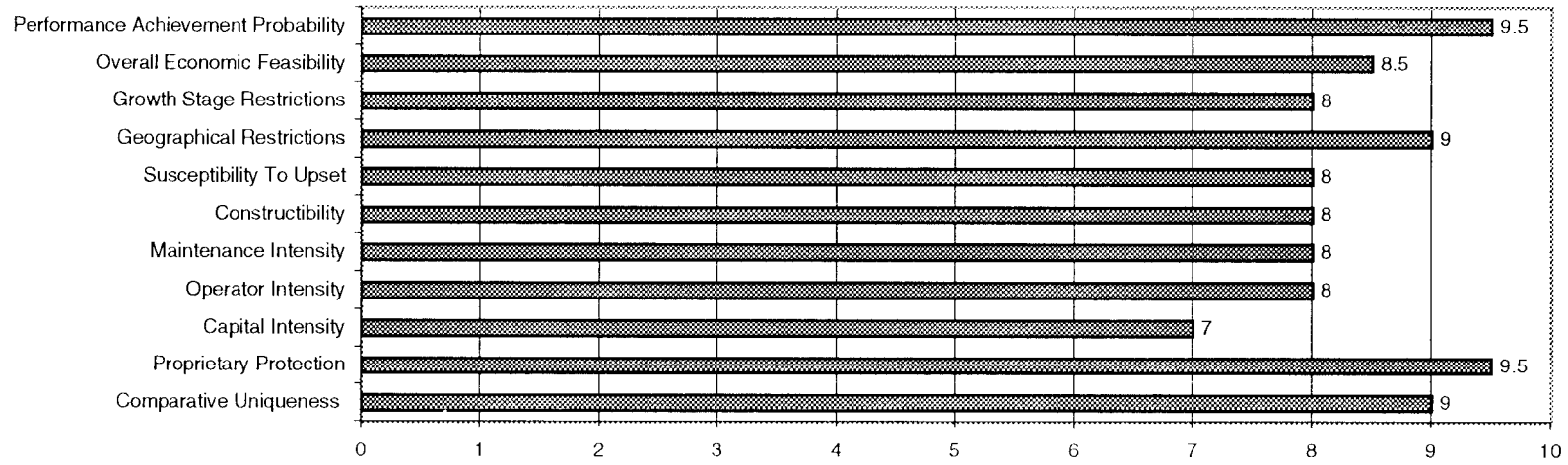
Typical Projected Construction Cost (Per Pig Basis): $ 9.29 Assumptions: 28000 total animals per year
Typical Projected Operation Cost (Yr, Per Pig Basis): $ 1.36

Net Present Cost Analysis:

Capital Cost	$ 260,000
Annual Operating Cost	$ 38,000
Net Present Cost	$ 585,260

Assumptions: The Net Present Cost Analysis assumes a useful life of the proposed technology of 15 years. The Annual Operation and Maintenance cost is converted to a Present Cost by utilizing a compounding rate of 8% interest over a 15-year analysis period.

Technology Summation: **Weighted Score** **8.4**



Note: Partially developed technologies are extremely difficult to quantify. Predicted success factors are not a guarantee that a given technology will perform favorably or unfavorably but, rather, an indication as to whether a technology demonstrates a propensity to be refineable to the point of practical and economical application. This evaluation was based on the available information in the proposal. Where definitive data was absent, assumptions were allowed; such assumptions were based on the current state-of-the art and good science. Atypical performance claims were not discarded, but it should be remembered that basic laws of Physics and Biochemistry cannot be contravened. Also, some technologies were not "new" but simply extensions of proven treatment techniques.