Bion Technical Summary Performance Report: Implications for Public Policy

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Bion Dairy has recently published the results of a seven-month performance evaluation of its full-scale CAFO waste treatment installation at the 1,250-cow DeVries Dairy (DVD) in Dublin Texas.

The Bion system at the DVD was operated to maximize phosphorous (P) removal from the entire dairy effluent stream by biologically converting the bulk of the P into solids and nitrogen (N) into solids and nitrogen gas. It achieved an overall removal rate of 79% of the wastestream load P and 74% of the wastestream load N by incorporating a combination of screens and centrifuge technology to enhance solids capture after the biological process. The remaining P & N was discharged in the effluent stream to the storage lagoon to be utilized for irrigation of cropland. The quiescent conditions and retention time in the storage lagoon further polish Bion system effluent resulting in total system removals well in excess of 80% for both phosphorus and nitrogen. In addition, the system achieved substantial reductions for all air emissions. Relative to baseline air emissions for dairy operations, air emissions from the Bion system were 99.5 to 99.9% lower for ammonia, from 95 to 99.6% lower for oxides of nitrogen and volatile organics, and from 94% to 98% lower for H_2S.

The Bion system is specifically designed to work in conjunction with waste from a free stall dairy and is transportable to any CAFO waste stream.

Please refer to the following attachments to this document for more detailed discussion as follows:

- Attachment A: The Bion System Core Technology
- Attachment B: Implementation Options
- Attachment C: Performance Results
- Attachment D: Bion System Costs

The entire study is available on the Bion website: **http://www.biontech.com/**

As a technology provider, Bion has had the opportunity to interface with stakeholders to the issues of dairy industry nutrient and air emissions, including producers and their trade associations, regulatory and public policy makers and the environmental community. The difficulties of creating a “solution” by effectively integrating a proven technology into an existing operation, the impact on farm economics of the cost to implement, and the requirement for onsite skills to operate a compliance technology are real world issues.

We recognize that environmental concerns as well as the economics and scale of dairy operations vary significantly from region to region. While no set public policy approach will work everywhere, a set of public policy initiatives can be combined to flexibly support widespread compliance by industry participants across differing circumstances. Each region’s optimal mix of public policy and private industry action can evolve only through an informed process of dialogue among the stakeholders.

The existence of a demonstrated compliance technology holds significant implications for public policy formation. We offer the following discussion as a means to articulate options to be included in those dialogues. In the end, it will be a combination of public policy initiatives within each geographical area that will form the basis of support for widespread adoption by industry of proven compliance technologies.

Public Policy Implications: An Overview

Dairy operators throughout the country find themselves in the difficult position of being liable under federal law for environmental compliance while enumerated federal standards do not exist for dairy emissions. Federal lawsuits have already been filed against dairy operators in Texas, Idaho and Washington under the Comprehensive Environmental Response and Compensation and Liability Act (CERCLA). In addition, dairy producers can also be sued under the Emergency Planning and Community Right To Know Act (EPCRA).

Widespread compliance by the livestock industry with environmental requirements as promulgated by a spectrum of state, regional, county and local regulatory authorities faces two fundamental hurdles: certainty and cost. To achieve widespread acceptance and adoption of environmental compliance technologies throughout the industry, dairy operators need:

- Compliance technologies that are fully demonstrated so that the producer has confidence that it will achieve the mandated environmental performance;
- A transparent and stable regulatory environment, so that the dairy operator has confidence that his investment will provide a working solution over the long-term; and
- Affordability of the compliance technology, so that producers are financially able to implement a solution.

Up to this point, there has not existed a demonstrated technology capable of providing a comprehensive solution to the issues of air and nutrient emissions. Now that one has been shown to exist, the focus of necessity turns to the economics of implementation. In the end, the overriding issue for the producer will always be “how do we pay for it”!

The question will never be adequately addressed if left entirely to private industry. The challenge to establish economically viable solutions needs to be fully embraced by the regulatory community as well if it is to serve both environmental compliance and the economic realities of technology implementation. Any environmental solution that does not adequately address the issue of cost, short of a federally mandated solution, will inevitably cause large portions of the industry to resist or migrate to states (or in certain instances other countries) with lower cost environmental standards.

Using a Comprehensive Environmental Solution to Create Sustainable Incentives

The present system of government grants and subsidies that today effectively represents the only public support for environmental compliance is insufficiently funded to adequately support widespread compliance cost reimbursement across the industry. Only a comprehensive environmental solution, one that addresses both nutrient AND air emissions, will create the economic conditions within which “sustainable incentives” can be developed in support of widespread industry implementation. If a solution is fully vetted initially and capable of being monitored going forward, it will be able to support establishment of environmental standards that can result in sustainable incentives that make compliance affordable. In the final analysis, the regulatory community fundamentally holds the power to create the economic opportunity that will ensure implementation of working environmental solutions.

In its simplest form, “sustainable incentives” are regulations that recognize the need to support value creation to help pay for the environmental benefit that comes from widespread industry adoption of a solution. In essence, sustainable incentives need to create economic support for environmental compliance well beyond the present system of grants.

One important set of economic incentives would be creation of nutrient and Emission Reduction Credits (ERC’s) that provide a mechanism for producers to monetize a portion of the resulting environmental benefits to offset their compliance costs. This can only occur when:

1) Installation of compliance technologies by private industry supports discharges and emissions below reasonable environmental standards adopted through public policy; and

2) Compliance technology adopters have access to trading partners willing to monetize a portion of the environmental benefits created.

The specific determination of emission standards by regulatory agencies is a critical first step to the ability of CAFO operators to successfully comply from the perspective of both certainty and cost. Emission standards need to be set so that they achieve a balance that maximizes environmental benefit while at the same time creating enough economic incentive so that compliance becomes a viable alternative to litigation. Emission standards that do not meet the needs of the stakeholders will only result in continuing gridlock. Once balanced environmental standards are established, compliance will be driven by the economics.

However, it needs to be recognized that qualifying for the limited existing air emissions markets (ERC's) is difficult under the best of circumstances, while nutrient trading credits are essentially non-existent. The existing ERC trading structure did not contemplate participation by agriculture, and in many cases, the dairy industry is not located within air districts or watersheds where industrial players that might purchase these credits are located. In the case of nutrients, the problem manifests itself in basin versus watershed trading. N & P are not industrial water pollutants as much as they are municipal wastewater issues. For this reason, the customer or potential beneficiary may well be a large municipality or city in another watershed that is part of the same water basin.

As a result of these issues, producers will continue to be unable to monetize a portion of the environmental benefit from adopting compliance technologies even where reasonable standards are adopted. If credit trading is to become a contributor to the compliance cost equation, public policy must take into consideration the requirements of agriculture to participate in and benefit from appropriate nutrient trading and emission reduction programs.

Another potential economic benefit that can be derived from environmental compliance would be herd expansion for the individual dairy in conjunction with installation of a suitable compliance technology. Permits are issued on the basis of the environmental load to air and water. A technology that markedly reduces the load on a cow per acre basis creates the opportunity to increase the stocking density while still reducing overall adverse environmental impacts. Permitting herd expansion on a given footprint would provide the economic benefits from maximum utilization of the existing land and physical plant, similar to the leveraged economic benefits of a manufacturing facility operating three shifts. One example of a regulatory driven sustainable incentive would be regulations that fast track expansion permits in conjunction with adoption by producers of an environmental technology that meets all environmental requirements.

The resulting economic opportunity created will be recognized and pursued by both existing producers and supported by the existing and new sources of capital that would not be constrained nor prohibited from investing directly in the producer industry due to concerns for environmental liability.

As a result of developing a more realistic approach to supporting environmental compliance, historic science-based issues such as establishing a baseline for existing emissions will shift to real world questions such as:

- What emission standards can technologies actually provide that can be independently verified and subsequently monitored;
- At what cost; and
- How can those benefits be allocated through environmental reduction credits and sustainable incentives to achieve maximum environmental benefit at an affordable cost?

The Economics of Implementing a Solution

Historically, sources of capital to finance the implementation of environmental solutions have included federal and state grants or subsidized debt and private financing secured directly by the producers. Significant limitations exist in accessing the necessary capital based upon the cost / benefit trade-off of meeting existing piecemeal environmental requirements. In addition to the clarity and predictability needed to access capital, creating a **comprehensive** environmental solution directly provides the regulatory community with the ability to create the economic drivers that can and will support widespread implementation of the solution.

As already discussed, an important driver for the economic viability of an environmental solution comes from the ability of a dairy to optimize the use of its land and physical plant. Based upon input from dairy industry producers, accountants and financial institutions, herd expansion that is able to utilize existing milking parlor and land capacities would generate supplemental farm income based upon the reality that only about 75% to 80% of base herd operating costs are truly variable and actually accrue as costs to added milkers.

Calculations indicate that an individual dairy herd expansion between 4% and 12% of the base herd should support the capital and ongoing operating costs associated with the implementation of a Bion system as well as the cost for the modest herd expansion itself. These calculations are based upon the capital and operating cost for implementing a Bion system as discussed in Attachment D, the capital and operating costs associated with adding milkers, supplemental income from added milkers supported by lower per cow operating costs for additional cows after taking into account existing manure management costs.

Based upon Bion's documented nutrient removal and air emission reductions, existing dairies would actually be able to qualify for expansion beyond the modest level required to satisfy the cost of implementing a Bion system.

It is incumbent upon the regulatory and environmental communities to recognize the value of creating "sustainable incentives" based upon just this trade-off. Streamlined permitting processes that allow for contemporaneous expansion in a dairy herd in conjunction with implementation of a vetted comprehensive environmental solution would be a win / win for all stakeholders.

At the same time, it is incumbent upon producers to recognize that a combination of environmental credits and permitted increases in herd density in support of the costs for environmental compliance will result in reporting, monitoring and penalties for non-compliance historically reserved for industrial point sources.

Additional economic benefits from installation of a Bion system would be driven by the ability to access environmental reduction credits for both effluent nutrient and air emission improvements. Once balanced standards are set for air and nutrient emissions, environmental credits can become available to the private sector for implementation of technology that provides proven environmental benefits in excess of the standards.

Creation and support for emission and nutrient reduction credits through the setting of balanced air and nutrient emission standards once again provides a unique opportunity to the regulatory community to create sound environmental policy coupled with viable, private industry – based solutions that can work.

Conclusions

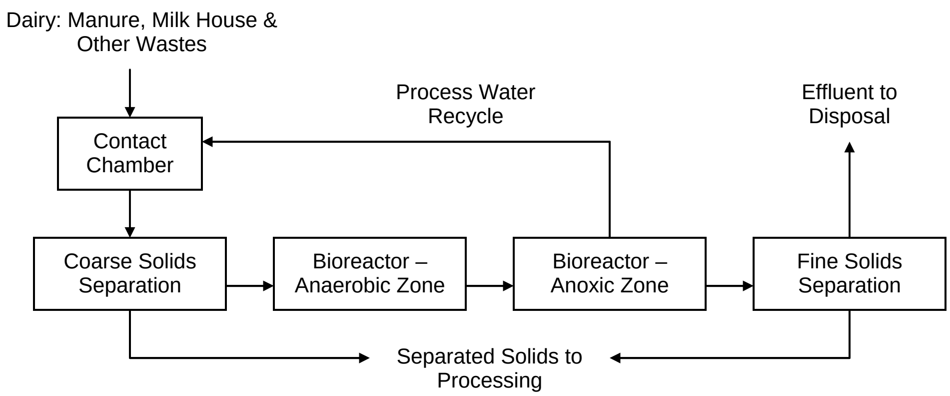
The Bion system creates and supports a number of key realities for a viable, private industry-based solution to the problem of emissions from livestock operations:

1. An economically viable, fully-tested, **comprehensive** environmental solution exists;
2. Its performance has been documented through a sampling and testing program with independently verified protocols;
3. It supports a range of implementation options that can address the specific environmental needs and circumstances of individual dairy or swine livestock operations across the country;
4. Cost of system implementation and operation can be offset through creation of "sustainable incentives" and the creation of Environmental Reduction Credits through the setting of balanced emissions standards; and lastly
5. The environmental regulatory community holds within its power the ability to create economic drivers that can result in widespread adoption of a comprehensive solution to the problems of air and water emissions from livestock operations in the United States without additional financial burdens to dairy owners or taxpayers.

Attachment A: The Bion Core Technology

The Bion Nutrient Management System waste treatment process is a biological nutrient removal process. In the Bion system, nitrogen and phosphorus is removed as particulate organics and nitrogen gas via multiple biological processes, including phosphorus uptake and simultaneous nitrification and denitrification. A simplified block flow diagram for the Bion process is provided in Figure 1.

Figure 1 – Bion Process Flow Schematic.



In the Bion treatment process, waste products from the dairy barns are collected and transported by flushing the floors and alleys with recycled, treated wastewater. In scraped floor systems, collected waste is discharged to a mix tank where recycled process water is blended with the waste stream. The recycled flush water and manure mixture is transferred to the Bion treatment units along with milking parlor wastewater.

In the flushing process, the manure (including urine) and waste feed, bedding and other barn wastes are thoroughly mixed with the recycled flush water containing Bion's adapted, concentrated, populations of microorganisms. Flushing barn wastes in this manner results in dispersion of the manure solids and other solid particles providing intimate contact with the microbial cells present in the recycled flush water. Also, with this mixing and contact during flushing, many soluble volatile products present in the wastes are biosorbed by the microbes in the flush water. The regular contacting and flush removal with the sorption of these polluting and odor causing substances are responsible for the low odor levels observed in the flush floor housing units served by Bion systems.

The mixture of recycled flush water and wastes from the barn and milking parlor flows by gravity or is pumped into the initial Bion treatment system unit processes, the contact chamber and coarse solids separation processes. Nutrients, including nitrogen and phosphorus compounds are sorbed, attached to, or otherwise associated with the separated solids, thereby being removed from the liquid wastestream with the solids. Influent solids are harvested on a continuous basis via a coarse screen.

The screened or clarified liquid fraction of the waste stream containing dissolved solids, suspended solids and a suspension of microbial cells flows to the next unit process in the Bion treatment system, the bioreactor. Depending upon phosphorus removal requirements, the bioreactor unit process may be a single or two-stage configuration. The two-stage configuration consists of an anaerobic zone followed by an anoxic treatment zone. With the two-stage configuration over 90% of the phosphorus in the waste stream leaves the process in a particulate, mostly organic form. Appropriate conditions are maintained in the anoxic zone of the bioreactor through a combination of mixing and aeration designed to provide the microbial process environment required for biological phosphorus uptake and simultaneous nitrification and denitrification. The principal advantage of a two-stage bioreactor over a single-stage one is enhanced conversion of soluble phosphorus to particulate form.

Bioreactor process water is either recycled for flushing the barns or blending with waste in a contact chamber prior to coarse screening. Bioreactor effluent is discharged to a storage tank or lagoon following the fine solids separation unit process. The fine solids separation unit process is where the majority of the phosphorus that is in particulate organic form is removed from the waste stream prior to discharge as final effluent. In locations where minimal phosphorus removal is required fine solids separation may not be required. In locations where higher levels of phosphorus removal are required; fine screens, low or high speed centrifuges, and filters are used to produce the required effluent quality. In some instances constructed wetlands are used in lieu of fine solids separation for effluent polishing. Irrigation rates of effluent from a Bion treatment system are based on acceptable agronomic nutrient application rates as with raw or conventionally treated manure. However, because the Bion treatment system can remove 80+% of the nitrogen and phosphorus from the liquid waste stream, much less land area is required for effluent disposal purposes than with conventional manure processing systems.

In addition to removing nutrients from the waste stream, a primary benefit of the Bion treatment system is that it essentially eliminates air pollutants typically associated with liquid manure handling systems at dairy and swine farms. This occurs because the large microbial biomass in the treatment system interacts with the odor producing substances, other volatiles and potential volatile producing precursors present, reducing their concentrations to very low levels and in many cases essentially preventing their volatilization. These materials are eventually metabolized and incorporated into the microbial biomass. Through this process these substances are removed from the treatment system as an integral component of BionSoil or released to the atmosphere as odor free metabolic by-products. The maintenance of appropriate populations of microbes insures that the majority of these air emissions from the system are carbon dioxide, water vapor, and dimolecular nitrogen gas. Emissions of ammonia, hydrogen sulfide, methane and non-methane Volatile Organic Compounds (NMOC's or VOC's) from the Bion process are substantially lower than for conventional livestock waste storage and treatment methods.

Attachment B: Implementation Options

The Bion system supports a platform implementation approach in which the core Bion system is coupled with additional technologies in order to address a broad spectrum of environmental requirements, depending upon the circumstances of each particular livestock operation. Some possible implementation platforms include:

- The addition of solids separation technology where environmental standards require the supplemental removal of nutrients (N and P) from the wastestream effluent. Depending upon the extent of nutrient removal desired, a Bion system can be coupled with a variety of screens, a centrifuge, filtration system or with membrane technology, specifically selected to provide the degree of solids separation required for the installation;
- The incorporation of anaerobic digester technologies that can provide required warming of the Bion system in colder climates as well as supplemental revenues where energy values support the use of generated electricity to offset on-farm use and / or sale of supplemental energy to the electric grid. Incorporating anaerobic digester technology into a Bion platform allows anaerobic digestion to be used to convert methane into energy while the Bion system attends to the remainder of emission reduction requirements not otherwise addressed, such as ammonia, other atmospheric emissions and phosphorus.
- The development of central Bion processing facilities can extend the efficiencies of scale to those smaller operations that could not otherwise justify the cost of on-site implementation of a comprehensive environmental solution.

The cost to adopt any specific environmental solution will be primarily driven by a cost / benefit analysis based upon the implications for the implementation platform required to address the specific set of environmental and operating conditions found at each livestock operation.

Attachment C: Performance Results

Bion Dairy is announcing the results from seven months of an extensive sampling and monitoring program at its operation on the 1,250-cow DeVries Dairy (DVD) in Dublin Texas. The Bion system at the DVD is designed to work only in conjunction with the waste from a free stall dairy and was operated to maximize P removal from the effluent stream.

Methodologies used to assess and quantify system performance for nutrients and air emissions have been approved by an independent, third party review team comprised of environmental engineers, university researchers and regulatory officials. The methodologies including the data assessment approach, sampling procedures, and laboratory analyses are specified in sampling and monitoring program outlines for nutrient and air emission assessments.

Process monitoring and operations data related to process nutrient fate had been collected on a weekly basis since Fall 2003, with comprehensive air emissions monitoring added on April 1, 2004.

Nutrient performance results: The core technology of the Bion system delivers 95% of the wastestream load phosphorus (P) and 56% of the wastestream load nitrogen (N) as particulate solids. An additional 40% of the wastestream N is converted to harmless nitrogen gas (N_2) through the process of biological nitrification / denitrification.

Utilization of a combination of screens and centrifuge technology, designed to take advantage of the particulate form of N & P allows the Bion system to achieve an overall removal rate of 79% of the phosphorous (P) and 74% of the nitrogen (N). Additionally, the quiescent conditions and retention time in the storage lagoon to which system effluent is discharged further polishes Bion effluent, resulting in total system removals well in excess of 80% for both phosphorus and nitrogen. The remaining P & N is available for irrigation in a cropping system.

Nutrient Management Incorporating Centrifuge Solids Separation Technology

	lb P/day	**lb N/day**
Load	180	1,529
Effluent discharge	38	396
Coarse solids removed	24	169
Fine solids removed	5	34
Centrifuge solids removed	113	324
N load converted to inert N_2 gas (by mass balance difference)	N/A	606
Total removed	142	1,133
Total percent removed	**79%**	**74%**

Air emission results: The results from the air emissions testing are indicated in the following table:

DeVries Dairy Summary Air Emissions		
Total System Average Emissions for the period from 4/20/04 to 7/15/04		
Parameter	**lb/day**	**lb/AU-year[c]**
Methane: CH_4	147.32	27.49 (21.74 since 6/11/04)
Hydrogen sulfide: H_2S	2.17[b]	0.40 (0.23 since 6/11/04)
Ammonia: NH_3	0.81	0.15
Nitrogen oxides: NO_X (NO_2 standard)	0.062[a]	0.012[a]
NMOC (C_5H_{12} pentane standard) A	0.10[a]	0.02[a]
Carbon dioxide: CO_2	3,319	621

[a] - Note that all measurements for NO_X and NMOC were non-detect. In adhering to standard laboratory practices, based upon the analytical method the non-detect concentrations are converted to ½ of the level of detection.

[b] – Parallel flux chamber monitoring following standard protocol was performed on 7/1/04 and 7/14/04. Total system emission results obtained for the flux chamber and (this project's protocol) were; 0.70 (0.96) lb H_2S/day and 0.55 (0.82) lb H_2S/day respectively. This indicates that the emissions monitoring system applied provided conservative high emission rates compared to the flux chamber approach.

[C] Emission rates are provided on a per Animal Unit (AU) basis which is the equivalent to 1,000 lb live animal mass.

Comparison of Bion system air emission results with baseline measures is indicated in the table below:

SUMMARY AIR EMISSION BASELINE COMPARISON			
Total System Average Emissions (lb/AU-year[b]) from **4/20/04 to 7/15/04**			
Parameter	**DeVries Bion System**	**Baseline**	**Reduction %**
Methane: CH_4	27.49 (21.74 since 6/11/04)	Up to 179	Up to 84 (Up to 87)
Hydrogen sulfide: H_2S	0.40 (0.23 since 6/11/04)	4 to 15	90 to 97 (94 to 98)
Ammonia: NH_3	0.15	74[c]	99.8
Nitrogen oxides: NO_X (NO_2 standard)	0.012[a]	0.22 to 4.4	95 to 99.8
NMOC: (C_5H_{12} pentane standard)	0.02[a]	6.3	99.7
Carbon dioxide: CO_2	621	N/A	N/A

[a] - Note that all measurements for NO_X and NMOC were non-detect.

[b] - Emission rates are provided on a per Animal Unit (AU) basis which is the equivalent to 1,000 lb live animal mass.

The trials showed significant reductions of polluting releases to both air and water. To summarize, the results validate previously published data on the Bion process and demonstrate emissions of less than one pound per animal unit per year each for hydrogen sulfide, ammonia and non-methane VOCs.

The entire report, with both air and water data, is available on the Bion Dairy website at:

http://www.biontech.com/

Attachment D: Bion System Costs

Cost for Bion systems is directly influenced by factors of climate and environmental requirements for the particular livestock operation. In its simplest form, a Bion system will remediate air emissions while converting essentially all of the load-P to particulate form and a majority of the nitrogen to particulate form and most of the remainder into nitrogen gas. In cold climates, the system will utilize a methane digester to maintain temperature for continuing biological activity. At DVD, the system was designed and operated to optimize P conversion to particulate form while incorporating a centrifuge to maximize capture of P within the solids.

On this basis, for example a 1,000 to 3,000 cow dairy installation in Texas designed to maximize nutrient capture will cost in the range of $500-$650 per dairy cow, depending upon site, size and other variables as mentioned. On the other hand, in California, the same installation without maximizing nutrient and salt capture would cost in the $400 - $500 per cow range.

Energy, the primary operating cost for a Bion system, would range from $5,000 to $6,500 per month for a 2,000-milker dairy with the full nutrient removal capability, assuming an energy cost of $0.055 per kWh.

As one examines these costs, it becomes obvious that a 2,000-cow dairy in California is not going to voluntarily spend the additional $150 per cow or $300,000 in capital costs and an additional $20,000 to 25,000 per year in energy costs just to maximize nutrient capture absent some sound cash flow reasons and / or regulatory requirements. At the same time, lenders are becoming concerned about the potential environmental cleanup costs if these dairies are sued and are forced into bankruptcy, whether nutrient emissions are currently regulated or not.

In the end, certainty holds value for all stakeholders to the issue. A balance of the environmental standards with the affordability to comply becomes a goal for all stakeholders to work together to achieve.