

## Vacuum Bubble<sup>®</sup> Technology (VBT<sup>™</sup>) in Confined Animal Feed Operations – A Case Study

### **Introduction**

Vacuum Bubble<sup>®</sup> Technology (VBT<sup>™</sup>) creates micro bubbles of air that are neutrally buoyant. The bubbles are created under a partial vacuum and, as a result, the internal pressure of the bubbles is lower than that of the surrounding water. Consequently, the bubbles collapse to an average dimension of 0.25 mm in diameter. Because of their small size and neutral buoyancy, the bubbles remain in the water for many minutes. These micro bubbles increase the oxygen transfer potential in the water which, in turn, enables aerobic bacteria to consume the organic waste in the water.

### **Challenges**

Dairies that are established as Confined Animal Feed Operations (CAFO) are faced with many challenges, particularly in relation to the management of waste. Three specific issues that are of concern to the dairyman are –

1. The control of emissions
2. Sludge reduction
3. Nutrient balancing

### Control of Emissions

When emissions are not controlled, the dairyman runs the risk of serious and numerous complaints that can escalate into law suits. Some of the emissions from dairy lagoons are composed of Volatile Organic Compounds (VOC) and are known to contribute to the

development of low level ozone. Air Quality boards are continuously monitoring these emissions from large dairy waste lagoons.

### Sludge Reduction

The challenges facing the dairyman in terms of the production of organic waste in a CAFO facility are the accumulation of sludge in the waste lagoon, the subsequent removal of excess waste, and the excavation costs that go with it.

### Nutrient Balancing

The excess water (flush water) at large dairy farms is typically used for crop irrigation. This brings with it its own set of problems. The application of excess flush water to the land adds certain chemicals to the soil resulting in higher concentrations than would otherwise exist. These higher concentrations ultimately leach out of the soil and into the ground water. To manage this impact, Water Quality boards continuously reduce application rates. Dairies are therefore required to develop and maintain a Comprehensive Nutrient Management Plan (CNMP) prior to using the flush water on the land. The nutrients that are of primary concern are Nitrogen and Phosphorus.

### **Background**

This case study describes the use of Vacuum Bubble<sup>®</sup> Technology (VBT<sup>™</sup>) at a milk cow dairy with 3,800 head of cattle in the western United States. This dairy uses a flush barn system, and the waste management is segregated into North and South treatment branches. Flush water at the rate of 200,000 gallons per day is accumulated and sent to a settling basin. This water is taken out of the settling basin, when required, to flush out the barns. The water is then pumped through a solids separator. The manure is collected and dried. The flush water is pumped into a second sump and on to a second mechanical solids separator where the solids are accumulated and dried. The dry manure is sold.

The remaining liquid portion is sent to a third sump where it is separated, half to the North leg and the other half to the South leg of the lagoon treatment system. Each leg of the waste treatment system is made up of a primary lagoon with a capacity of 2.5 million gallons. The overflow from this lagoon enters a secondary 2.5 million gallon lagoon, and the overflow from that lagoon enters a 20 million gallon storage lagoon. Historically, the primary and secondary storage lagoons were excavated once or twice a year, at a cost of approximately \$60,000 per year.

The water from the storage lagoon is used to irrigate 800 acres of crop land. The Water Quality Board regulates the nutrient concentrations of this water based upon the application per acre of land. These regulations have meant that the dairyman has had to remove some of this stored liquid because the nutrient concentrations exceeded those permitted for application on the 800 acres. The removal and transportation of this water has cost \$50,000 per year.

## **The Study**

The dairyman was faced with a number of challenges. These included the rising costs associated with the accumulation of sludge and its subsequent removal, and the pumping and transportation of excess water. His interest was in reducing these costs. The dairyman was introduced to Vacuum Bubble<sup>®</sup> Technology (VBT<sup>™</sup>) as a potential solution to these problems. A two-phase evaluation of VBT<sup>™</sup> was conducted.

## **Evaluation**

### **Phase I**

#### Objective:

To demonstrate, using VBT<sup>™</sup> aeration, a reduction in the sludge in a static lagoon with a capacity of 2.5 million gallons.

Method:

The lagoon contained manure (sludge) to a depth of 15 feet with 4% to 5% solids. Five feet of process water was added to the lagoon so that the VBT™ could operate. At the end of September, 2005, five VBT™ Model 601 Series aerators (3HP each) were installed, and a microbial inoculum was introduced into the lagoon.

Results:

The five VBT™ aerators ran continuously in this lagoon from the end of September, 2005 to the end of January, 2006. With the use of VBT™, the sludge was reduced from a depth of 15' down to 3' in approximately 120 days. At the end of Phase I the sludge depth readings were from 6' to 8' in the untreated primary lagoon and from 3' to 4' in the secondary lagoons.



Day 0 Sludge Level 15'



Day 120 Sludge Level 3'

The success of this 4 month evaluation led to a full service installation of 19 VBT™ Model 601 Series aerators in the lagoon treatment system. The 19 aerators were distributed as follows –

- 5 in each of the primary lagoons (10 VBT™).
- 3 in each of the secondary lagoons (6 VBT™).
- 3 in the storage lagoon.

To further evaluate the on-going reduction of sludge in the lagoon treatment system during Phase II testing, sludge in each of these lagoons was measured on multiple occasions and in

numerous locations with a sludge judge. During the ensuing year (Phase II) sludge layers were constantly maintained at 2 to 3 feet in all lagoons. For over 3 years following the Phase II study, the dairyman has not excavated or pumped solids from any of the dairy's lagoons. This represents a savings in excess of \$200,000.

## **Phase II**

A second study of wastewater treatment with VBT™ was then launched at this dairy in February of 2005 and ran until the end of February, 2006.

### Objective:

To reduce the nutrient content (Nitrogen and Phosphorus) in the discharge/irrigation water from the lagoon treatment system in order to meet the land application rates specified in the dairy's comprehensive nutrient management plan (CNMP). In addition, the dairyman wished to reduce the nutrient content such that the wastewater may be applied to the dairy's 800 acres with no excess wastewater to be hauled to additional sites. This represents a reduction of 400 acres in required land application.

### Method:

Sampling and testing was performed by an independent, certified laboratory throughout the testing period. Samples were collected at the inlet and outlet of each lagoon and at the point of discharge/irrigation. Multiple grab samples from each lagoon were mixed to generate a single "composite" sample for testing. All resulting samples were put on ice for transport to the laboratory for analysis.

### Results:

The following table represents a summary of the average influent and discharge wet lab results for the samples taken during the year long study.

| <b>Analysis of Water Quality - California Dairy Farm</b> |                         |                          |                 |
|--|-------------------------|--------------------------|-----------------|
| <b>January 5, 2005 to February 24, 2006</b>              |                         |                          |                 |
| <b>Variable</b>  | <b>Average Influent</b> | <b>Average Discharge</b> | <b>% Change</b> |
| NO <sub>3</sub> -N                                       | 2.02                    | 0.34                     | -83.16%         |
| NH <sub>4</sub> -N                                       | 322.88                  | 367.30                   | 13.76%          |
| TKN  | 844.56                  | 446.80                   | -47.10%         |
| TS   | 12,796.69               | 4,345.60                 | -66.04%         |
| Ca   | 334.19                  | 181.70                   | -45.63%         |
| Mg   | 175.81                  | 105.70                   | -39.88%         |
| Na   | 225.63                  | 189.50                   | -16.01%         |
| TP (Total phosphorus)                                    | 109.14                  | 36.47                    | -66.58%         |
| TK (Total potassium)                                     | 791.21                  | 619.20                   | -21.74%         |
| CaCO <sub>3</sub>  | 2,926.75                | 2,767.10                 | -5.45%          |
| Cl   | 276.88                  | 224.00                   | -19.10%         |
| SAR <sup>1</sup>   | 2.78                    | 2.35                     | -15.51%         |
| BOD  | 3,650.0                 | 369.90                   | -93.66%         |
| TSS  | 10,139.66               | 1,757.17                 | -81.24%         |
| TVSS   | 7,089.67                | 1,268.67                 | -82.11%         |

1. Sodium Adsorption Rate (SAR) is the index used to express the relative concentration of sodium to calcium and magnesium.

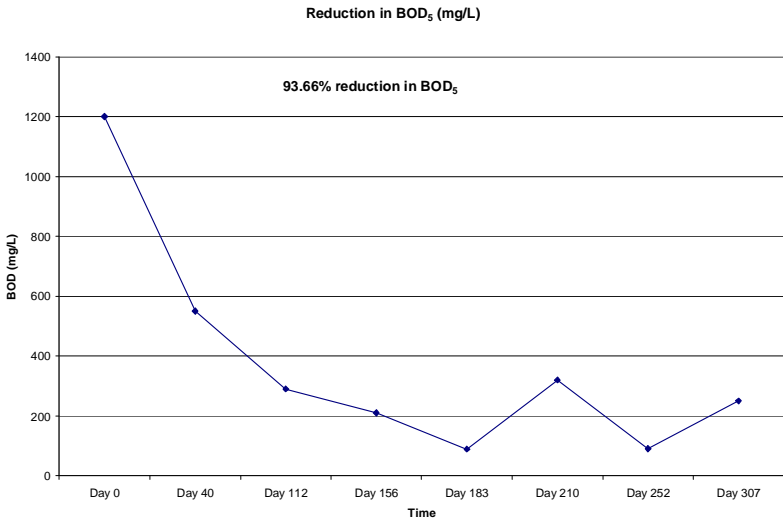
### BOD Reduction

At the beginning of the Phase I evaluation, the organic waste (BOD<sub>5</sub>) in the upper water was at 3,500 mg/L. After four months of aeration, VBT™ reduced this to 500 mg/L. The reduction in BOD<sub>5</sub> during Phase I was significant not only for the organic waste reduction, but also in that VOC emissions were significantly reduced. Independent studies by UC-Davis have shown the direct correlation between reduction in BOD and reduction of VOC.

*“70% BOD<sub>5</sub> removal in dairy manure can reduce certain VOC emissions by about 70%”*

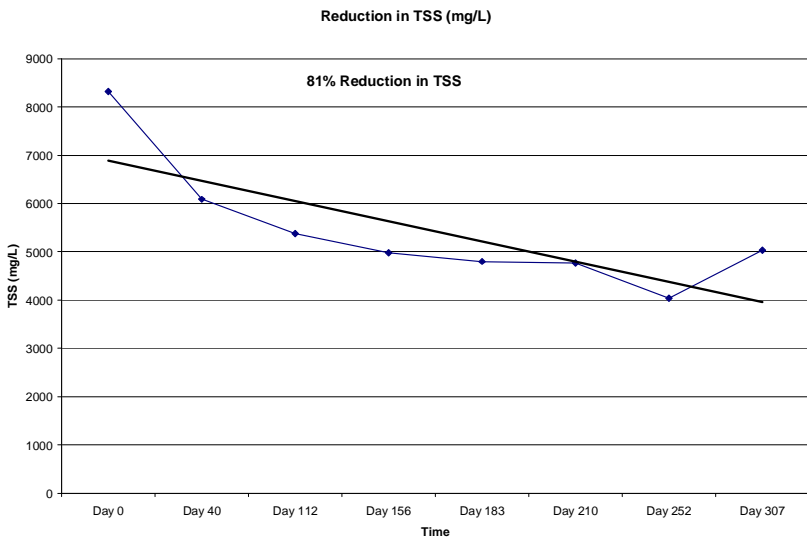
University of California, Davis presentation, 2006.

During the year long Phase II testing, the BOD<sub>5</sub> values entering the primary lagoons ranged from 3,000 mg/L to 6,000 mg/L with an average of 3,650 mg/L. BOD<sub>5</sub> discharged was approximately 369.9mg/L, or an 93.66% reduction.



**Total Suspended Solids (TSS)**

Total Suspended Solids (TSS) were monitored during Phase II testing to determine the efficacy of the VBT™ treatment on reducing the accumulation of solids or sludge. TSS is the precursor to the formation of sludge layers and any reduction of TSS reduces future sludge production. During the year long Phase II testing TSS values in the primary lagoons ranged from 4,700 mg/L to 16,400 mg/L at an average of 10,140 mg/L. TSS discharge was approximately 1,750 mg/L. or an 81.24 % reduction



## Nutrients

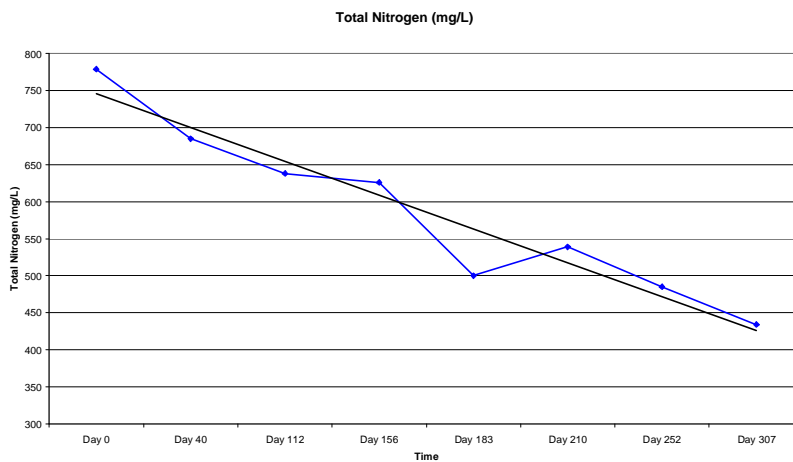
### Nitrogen

At the beginning of the study -

Total Kjeldahl Nitrogen (TKN) levels were at 780 mg/L. These were reduced to 485 mg/L.

The average TKN entering the primary lagoon for the life of the study was 818 mg/L.

The average value of TKN discharged to the field was 485 mg/L.

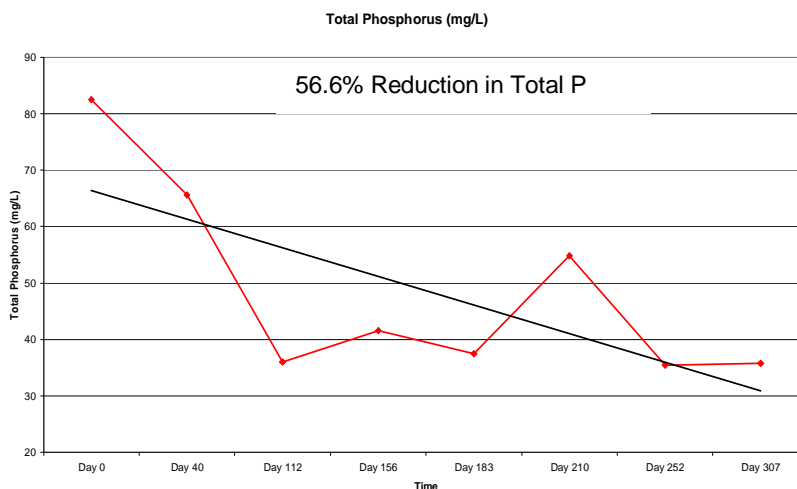


Ammonium levels were at 536mg/l and these were reduced to 310 mg/L.

The average value of ammonium entering the primary lagoon, for the duration of the study, was

320 mg/L. The average value of ammonium discharged to the field was 310 mg/L.

### Phosphorus



## **Conclusion**

The study has shown that the use of VBT™ for aeration in a dairy facility brings about a series of positive results that benefit the dairyman and the environment. Since the Phase II study was concluded at the end of February, 2006, the VBT™ aerators have operated in continuous mode in these lagoons. The long-term results are that the solids levels in the respective lagoons have remained constant at around 2' to 3' deep. The dairyman has not had to excavate nor has he had to drain the lagoons – saving over \$60,000 per year. Following the study, in the period February, 2006 to August 2007 the dairyman continued to meet the CNMP application rates. Consequently there has not been the need to pump and transport liquid, at a saving of \$50,000 per year.

The dairyman has realized additional benefits from the use of VBT™ in his lagoons. Crop yields have increased, and an Agronomist associated with the study has asserted that the primary reason for increased crop yields is that the nitrogen applied to the land has been converted to a more plant ready form of ammonium and organic nitrogen, both of which are insoluble. Consequently they are more readily available for uptake by plant roots, and do not run off or leach into the ground water. There has also been a significant increase in the heterotrophic plate count indicating the introduction of active, beneficial microbes back into the soil to promote an improved symbiotic relationship between the growing plants and a healthy bioflora in the soil.