



A COMMERCIAL APPLICATION OF
VIROFLOW™ TECHNOLOGY

CASE STUDY MURPHY BROWN HOG FARM, IVOR, VA

“ViroFlow™ Technology, using ViroPhos™ reagent has an excellent ability to bind soluble phosphate, while still allowing it to be bio-available to plants.”



The main entrance to Murphy Brown Hog Farm

OVERVIEW

Murphy-Brown, LLC was formed in 2001 when Smithfield Foods acquired, and combined Brown's of Carolina, Carroll's Foods, Murphy Family Farms, and Circle Four Farms, creating what is sometimes referred to as Smithfield Foods Hog Production Group. Murphy-Brown's objective was to assess whether ViroFlow™ Technology could reduce total phosphorous concentrations in nutrient rich water derived from their animal waste streams.



ViroPhos™ reagent was applied in slurry form.

At the same time, Virotec set its own objective to demonstrate that its technology also has the capability to further reduce available forms of nitrogen.

CHEMISTRY OF VIROPHOS™ REAGENT

ViroFlow™ Technology using ViroPhos™ reagent reduces the soluble inorganic phosphorous content in sewage effluent to the minimum theoretical solubility limit for phosphate precipitates.

In turn, up to 85 percent of the phosphate nutrient is transferred to the ViroPhos™ reagent enriched bio-solids in a remarkably stable form, where it remains stable even in anoxic conditions.

ViroPhos™ reagent enriched bio-solids also retain phosphate, ammonium, calcium, magnesium, potassium and other essential macro- and micro-nutrients in non-leachable, plant available forms.

BACKGROUND

Murphy Brown is comprised of five separate farms, each housing approximately 1000 sows. The animal waste is separated from hogs and piped to anaerobic lagoons, typically earthen structures. Supernate from these lagoons are then pumped to irrigation retention ponds. This particular study was conducted at Farm #1.



Murphy Brown is located in Isle of White County, Ivor, VA USA.

The Farm #1 retention pond holds supernate pumped from anaerobic lagoons P1 and P2. Waters are then applied through irrigation to crops such as corn, soybeans, Coastal Bermuda grass or other crops. Factors such as climate, area agricultural practices and regulatory requirements must be considered before nutrient rich waters can be utilized in this manner. In particular, the regulated limit for total phosphorous (P) is 100 mg/L.

TREATMENT METHODS

Remedial phosphate treatment was carried out by spraying ViroPhos™ reagent over the dams. Two separate treatments were performed by Virotec. All samples were taken from a previously

designated sample point; located near the inflow pipe on the south side of the retention pond. Sampling was conducted by Virotec and Murphy-Brown, LLC. Analyses were performed by two separate independent laboratories.



Spray application of ViroPhos™ reagent.

RESULTS

>Phosphorous Removal

ViroFlow™ Technology removed 66% Total P over the span of the trial. The initial stage of treatment resulted in a slight increase in total phosphorous concentrations across the sediment/water interface causing repartitioning of phosphate from the sediment and pore waters to the overlying lagoon water. However, the initial treatment was sufficient to remove the phosphate released from the sediment. The final treatment was applied approximately 30 days later to address additional organic loading introduced into the lagoon and to further reduce the initial levels.

Total P (elemental form) and *P2O5 (oxide form) were measured by Murphy Brown, total P and ortho-P (soluble) were measured during Virotec sampling events. Table 1 and Table 2 summarize both sets of phosphate treatment results.

*P2O5 is the oxide form of P and is commonly used to determine fertilizer application rates. Conversion between oxide and elemental forms can easily be made by multiplying P2O5 by 44%

TABLE 1: MURPHY BROWN, LLC TOTAL P AND P2O5 DATA

Date	Total P mg/L	P2Os lb/kgal	Hydraulic Loading MG
10/11/2006	68.9	1.32	0.090
10/19/2006	78.5	1.44	0.450
11/03/2006	49.5	1.119	0.810
11/17/2006	45.2	1.08	-
11/22/2006	33.9	1.20	0.420
11/30/2006	28.4	1.26	0.855
12/14/2006	23.3	1.11	0.300

TABLE 2: TOTAL P AND ORTHO-P DATA
 Murphy Brown 8501 - Farm # 1 Holding Pond

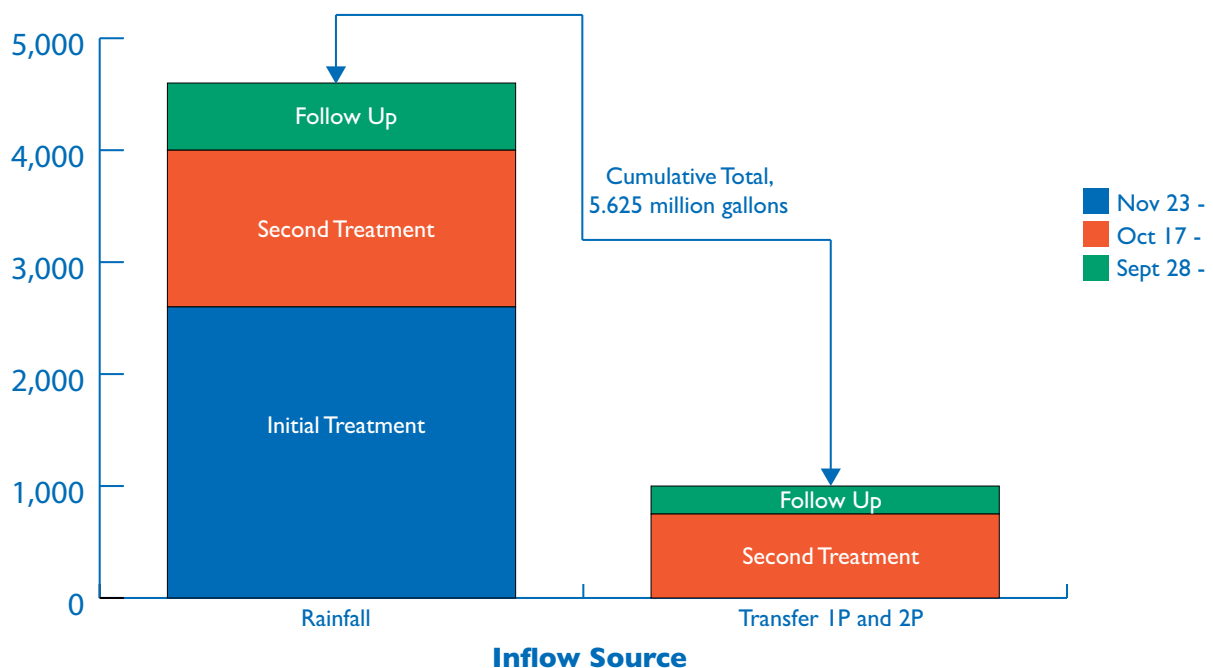
Date	Total P mg/L	ORTHO-P mg/L
09/28/2006	73.5	-
10/19/2006	53.4	65.7
11/20/2006	26.8	36.6
12/05/2006	24.0	25.0
1/11/2007	20.2	24.3

> **Hydraulic Loading**

Based on data provided by the customer, 1"=.150 million gallons (MG), the retention pond is capable of holding approximately 12.5MG before irrigation pumps are required to be turned on.

The volume observed during the initial survey was 4.8MG; however a significant rainfall event, coupled with a few lesser events, resulted in the lagoon level increasing to 9MG and a dilution of the overall total P and nitrogen concentrations. Over the testing period the retention pond maintained a level of approximately 10MG. Figure 5 (below) summarizes hydraulic loading from rainfall and waste transfers from P1 and P2 lagoons over the period of the study.

Figure 5 - Hydraulic Loading Data - September 28 - December 14, 2006
 Murphy Brown 8501 - Farm #1 Holding Pond



> Nitrogen Removal

ViroFlow™ Technology chemically removed nitrogen species by 70% (table 2, ammonia-N), through reaction between the ammonium radical and ViroPhos™ reagent.

These reagents also consist of a cocktail of very fine grained minerals which can have a positive or negative surface charge depending on the pH conditions they are exposed to. The very fine grain size of the mineral particles gives them a high surface area to volume ratio and a high surface charge to mass ratio. These properties make the reagents extremely surface active, giving them the ability to attract and hold charged particles or polar molecules. The reagents enhance precipitation, co-precipitation, coagulation and improve flocculation, resulting in denser agglomerates which settle rapidly. Both suspended solids and organic matter were also removed from the liquid stream.



Influent pipe

TABLE 3: NITROGEN REDUCTIONS, FARM # 1 RETENTION POND

Date	Nitrogen lb/kgal	*Ammonia-N mg/L	TKN mg/L
09/20/2006	-	81	294
09/28/2006	-	225	311
10/11/2006	1.32	45	356
10/17/2006	-	-	-
10/19/2006	-	243	1
10/19/2006	1.50	104	346
11/03/2006	0.95	48	284
11/17/2006	0.86	60	258
11/20/2006	-	117	-
11/21/2006	0.65	53	288
11/30/2006	0.54	84	303
12/05/2006	-	250	-
12/14/2006	0.45	25	266
01/11/2007	-	197	-

*Hydraulic/organic loading and ViroFlow™ Technology - treatment events can be directly correlated to the rapid increase in ammonia-N depicted in Table 3 and Figure 8.

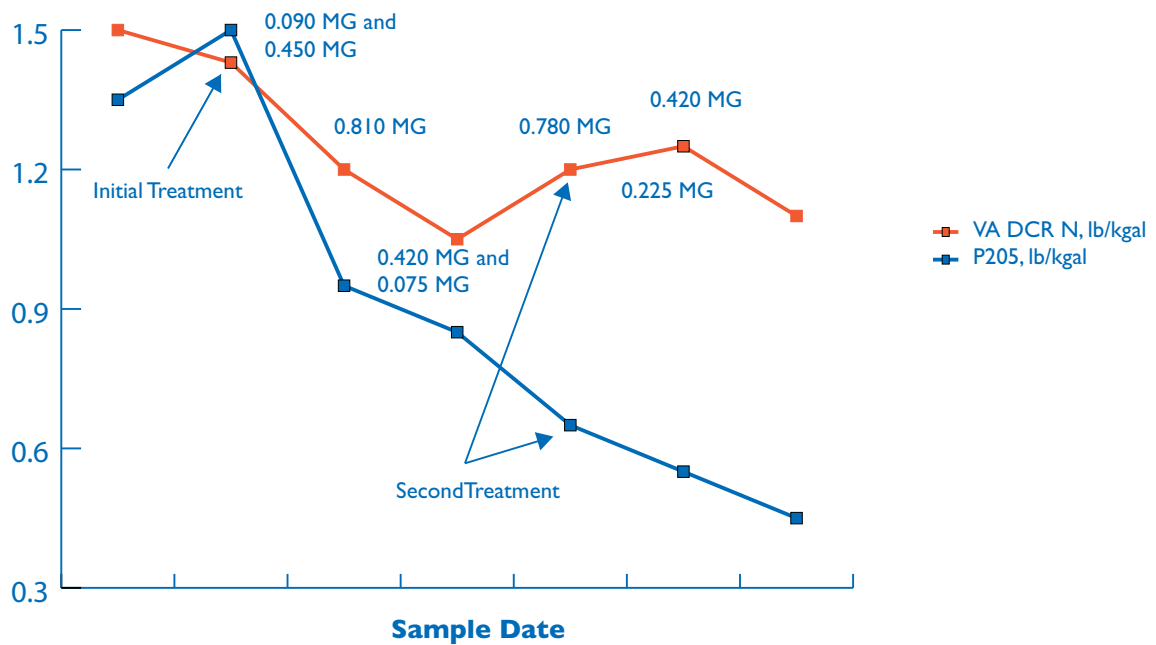
CONCLUSION

ViroPhos™ reagent was able to significantly reduce both nitrogen species and phosphorous compounds, not only in the overall lagoon waters, but also in the additional organic loads transferred from P1 and P2.

Figure 8, below, reflects the overall reductions when coupled with product application and wasting events. Trend lines also reflect a continual reduction 2 months after treatment.

N and P levels can, at the least be maintained at these levels or even reduced further through the implementation of a ViroFlow™ Technology treatment program.

**Figure 8 - N (available) and P (expressed as P205) Reductions
- ViroPhos™ Technology
Murphy Brown 8501 - Farm # 1 Holding Pond**



Lagoon scale, inches.