<u>Use of BAT 506 to Control Odors in Biosolids Composting</u>

"A Preliminary Report Describing Odor Reduction and Economic Impact from the use of BAT 506 (a product of Global Odor Control Technologies, LLC) at Purdue University's Full-Scale Composting Facility"

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Introduction

In 1994, Purdue University in collaboration with Eli Lilly & Co. began to develop a waste utilization program for managing several different by-products. These by-products included coal ash from the power plant at Purdue and biosolids from an antibiotic production process at Eli Lilly & Co. In 1997, we implemented a full-scale composting facility to handle biosolids, coal ash, and local municipal yard waste. We called this operation "SoilerMaker" and our objectives were to take waste materials, process them, and create topsoil and soil amendments.

From our earliest field trials, our composting operation suffered significantly from odors problems that resulted from the decomposition of the biosolids. Our first facility was closed within six months due to odor complaints. We built a new facility further away from campus residences and modified our process but still suffered from odor complaints. In March of this year, we began experimenting with a commercial odor control product manufactured by Global Odor Control called BAT 506. This report describes the odor reduction and economic impact from using this product.

Purdue University's SoilerMaker Facility (October, 2000)

Purdue Composting Operation – "SoilerMaker"

The Purdue SoilerMaker operation seen above utilizes several different types of materials as feedstock for composting. Besides coal ash and biosolids we also handle yard waste and animal bedding. The volumes and sources of these materials are given in Table 1. We use basic windrow composting methods at our facility to produce about 10,000 tons of finished compost each year. Mature compost is blended with natural soil to produce about 20,000 tons of synthetic topsoil. Purdue uses this soil on campus and for reclamation and development of a sand and gravel quarry intended for future campus expansion.

Table 1
Source and volume of feedstock materials used for composting at Purdue University

Material	**Source(s)**	**Volume / year (tons)**
Coal ash	Purdue	600
Fermentation biosolids	Eli Lilly & Co.	1,200
Leaves	Lafayette, West Lafayette, Purdue	10,000
Straw (animal bedding)	Purdue Veterinary Hospital	500
Tree limbs (brush)	Purdue, West Lafayette	3,000
Total		15,300

Odor Problems

The composting operation has suffered from odors generated in the decomposition of the biosolids. The biosolids are produced from an anaerobic fermentation process used to manufacture an antibiotic. The composition of the biosolids and other feedstock are provided in Table 2. The organism that produces the antibiotic is grown on a food substrate containing several raw ingredients including: corn gluten, fish meal, lard oil, peanut meal, soybean floor, soybean meal, and soybean oil. During our field trial and pilot mixing operation we received several dozen complaints about the odors coming from our site. The odors produced were highly offensive and many people complained of "dead body" odors. This suggested the presence of compounds such as cadaverine and putrescine.

As we developed our full-scale operation we continued to modify our process and recipe in an effort to control odors. Some of the solutions we tried included increasing the frequency of windrow turning, and increasing the volume of woodchips in the recipe to improve pile porosity. None of these solutions alleviated our odor problems.

In April 1999, six months after we opened our first full-scale site we were forced to suspend the operation and relocate to a new site located about 1.5 miles further away from campus. During the development and construction of this new site, we continued to work on recipe design and compost methods since an enclosed facility with air scrubbers was not economically feasible. We found that windrow turning generally increased our odor production because the volatile compounds were dispersed into the air along with the steam.

Table 2 Composition Analysis of Feedstock (as is basis) (Woods End Research Laboratories, Inc.)					
Variable Measured	**Coal ash**	**Fermentation biosolids**	**Leaves**	**Straw (animal bedding)**	**Tree limbs (brush)**
Density (lbs/yd^3)	1790	1685	489	169	623
Solids (%)	89.5	23.9	38.0	47.4	52.6
Moisture (%)	10.5	76.1	62.0	52.6	47.4
Inert Matter (%)	--	--	0.6	--	29.4
pH (1:1 H_2O)	12.26	5.14	8.36	8.75	7.17
Organic Matter (%)	--	20.1	23.6	43.0	50.4
Conductivity (mmho/cm)	--	3.8	1.6	3.3	0.5
Carbon:Nitrogen (C:N) w:w	--	8.9	26.8	57.2	228.2
Total Nitrogen (%)	--	1.216	0.474	0.406	0.119

One alternative that worked reasonably well to decrease odors was to mix the biosolids with woodchips and compost them in a static pile. We covered these piles with leaves to act as a biofilter and did not disturb them until odors were diminished. The decomposition of the biosolids still produced odors but since the piles were not disturbed, the odors did not travel further than 30 to 50 feet. After six to eight weeks, the biosolids/woodchips were mixed with straw and leaves and finished as windrows.

Although we had fewer odor complaints from our neighbors, visitors to the site still noticed the odors. There were also several drawbacks to this composting method. The process increased the amount of material handling required, and it lengthened the composting time by more than two months. The windrows took longer to reach thermophilic temperature, the rows didn't maintain this temperature for more than a few weeks, and the compost took longer to finish out. Also, the finished quality of the compost was not as good because, there was a higher concentration of larger wood chips remaining in the compost (we currently do not screen our product). We continued to search for a solution that would allow us to use fresh biosolids in the windrows without causing odors.

Global Odor Control BAT 506

In February, 2000 Mr. David Hill with Global Odor Control Technologies, LLC, spoke at a seminar in Lafayette, Indiana sponsored by the Indiana Recycling Coalition. Mr. Hill gave a presentation on odor prevention at composting sites, and afterwards he was invited to visit Purdue University's composting operation and test some of his company's products. He first visited our site March 29, 2000 and brought a product called BAT 506, a liquid that is added to compost piles to reduce odor production.

We tested the 506 in two piles of about 100 yd^3 each. One pile was made with 30% each woodchips, straw, leaves and 10% fresh biosolids. The other pile was made from 50% leaves, 30% straw, and 20% fresh biosolids. Our objectives were to 1) add fresh biosolids without causing odors, 2) increase the volume of biosolids in the recipe, and 3) make compost from only straw and leaves. Based on our observations of odors from the piles we found BAT 506 to be very effective at reducing odors from our compost. One month later we began testing the product in full-sized windrows. We made several changes to our composting methods when we began using 506 (see Table 3).

Observations

We have not had a single odor complaint from our neighbors since we introduced BAT 506 into our composting process. The only odors we have noticed from the treated compost is an initial manure-like smell that can last for up to 3 days. None of our treated rows have the offensive odors characteristic of untreated compost made with fresh biosolids.

We observed some differences in temperatures of the compost. The temperature of the treated piles did not rise as quickly and the peak temperatures were lower than what we previously observed in our compost process. Temperatures in compost piles made with fresh biosolids normally reached 150^{o}F to 165^{o}F within one to two days. Temperatures in treated piles are generally about 10^{o}F lower, ranging between 120^{o}F and 140^{o}F during the first few days and then increase up to 150^{o}F for the remainder of the 28 days. When the rows are turned at 28 days we see pile temperatures go as high as 160^{o}F for several weeks. Pile temperature is highly dependent on moisture.

Row temperatures in our test piles may have risen more slowly because of low moisture content in the feedstock. After we applied 600 gallons of water to the surface of the piles we saw a rapid response in increased in pile temperatures. We have also noticed that there is a greater formation of white fungus in the treated compost and it extends deeper into the pile than observed under untreated conditions.

Current Production

Between March and May of this year we built 16 new rows of about 250 yd^3 each, fine-tuning our recipe and methods. These rows have since finished active composting and have been tested and placed into curing. Since June we have built 40 additional new rows using BAT 506. We have not received a single odor complaint at our composting site. Visitors at the site have even commented on what a good job we do controlling odors.

Rows treated with BAT 506 are still constructed with the same methods as previous but with slightly more initial turning and watering (see Table 2). Once a row is built the BAT 506 liquid is added into the water tank and sprayed into the pile as it is turned. We add the dosage of 506 into approximately 1,000 gallons of water and spray it into the pile as we turn the last time. We then cover the pile with leaves as a biofilter and let it compost statically for 28 days. The biofilter we use limits initial manure-like odors that form during the first few days when the pile is heating and the BAT 506 is starting to work. If leachate forms or manure smells become strong we spray the pile with a topical treatment called BAT 505. This product works very well to eliminate ammonia. It also helps to reduce the fly population that forms on the surface of the rows.

Table 3 Composting methods before and after using BAT 506	
Before	**After**
Compost Pile Formation. The operators use a front-end loader and silage wagon to place woodchips, leaves, and straw into windrows. A tractor and an Aeromaster PT-120 compost turner with water tank are used to turn, water, and mix the materials (usually 4 to 6 turns). The biosolids and fly ash are added to the carbon-rich amendments and the row is turned another 2 to 4 times to mix. Final row size is approximately 3.5' tall, 12 feet wide and varies in length depending on the width of the compost pad.	*Compost Pile Formation*. We start new windrows with the same process except we turn new rows slightly more to mix (6 to 8 times). Once the biosolids have been added to the row we use the water tank to dose the row with 506. The liquid product is added to the water tank along with 1,000 gallons of water and sprayed directly into the row. After dosing the row we cover the row with 6" of leaf mulch as a biofilter. If needed, we use a topical spray called BAT 505 to control ammonia odors during the first few days..
Pile monitoring. We monitored the rows daily for temperature and CO_2 and turned rows when CO_2 was higher than 15%.	*Pile monitoring.* We reduced monitoring from daily to weekly and we continue to monitor for temperature and CO_2.
Pile Turning. Piles were turned (and if necessary watered) using the tractor, compost turner, and water tank. This occured daily during the first month of composting; slowing to weekly as the pile completed the composting process. The most active phase of the composting process was completed in 6 to 8 weeks. A typical row would be turned 20 to 24 times in the first two months.	*Pile Turning.* Rows are left to compost as static piles for at least 28 days. After 28 days they are turned and watered 6 to 8 times during the next two months. Each row is turned 6 to 8 times during its active composting phase, generally only when water is needed. After three months the rows are stockpiled for curing.
Combining Rows. After two months of composting the rows had shrunk significantly and two rows were combined into one. Once combined, rows were turned as needed (3 to 4 times) until they were stock piled for curing.	*Combining Rows.* Rows start out larger due to the addition of a biofilter. We no longer need to combine rows prior to curing.
Curing. Each row was sampled prior to curing and submitted to a commercial lab for compost analysis. Compost remained in curing for three to six months prior to blending with soil.	*Curing*. Same process is followed.
Soil Blending. After curing, the compost was blended with 40% natural soil (subsoil) to make synthetic topsoil. The tractor and compost turner were then used to blend the compost and soil. The resulting blended soil was used on campus and in the gravel pit for reclamation.	*Soil Blending*. Same process is followed.
Reporting Requirements. Because we utilize industry waste materials we are required to have a marketing and distribution permit issued by the state. Our permit requires monthly testing of metals and available nutrients in the finished compost reported annually.	*Reporting Requirements* are the same.

The addition of the biofilter also allows us to build larger rows than previously because we are not limited to the size of our compost turner. After the rows have composted for 28 days, they shrink down to a size that fits our turner. In this way we have been able to get more material into each row and build rows large enough that even after shrinkage has occurred we do not have to combine them.

The biggest difference our composting method is that we no longer turn new rows. Once a pile is treated it is covered with leaves and left to compost statically for 28 days. Recommendations made by compost turner manufacturers are to turn new rows daily to aerate the new rows. We have found that this amount of turning is not necessary in order to produce high quality compost.

Our new recipe still utilizes woodchips since this material comes from campus tree trimmings and is one of the campus wastes we are designated to handle. However, we were able to make compost recipes with no woodchips and still have successful odor control. We were also able to make mixes with higher volumes of biosolids, but we found that adding higher volumes of biosolids resulted in more leachate from the rows and the finished compost had higher nitrogen concentrations. Another difference we noticed was higher ammonia concentrations, which limits the application rate of our finished compost as topsoil. Our permit limits the volume of compost we can apply depending on plant available nitrogen. Ammonia is very soluble and so higher concentrations increases plant available nitrogen. If a producer wanted a product that had higher fertilizer value this would be a positive factor. But since we want to use large applications (up to 500 tons per acre) we do not want high nitrogen concentrations.

We also noticed a higher fly population on site that was most likely due to higher ammonia concentrations and less windrow turning. Windrow turning eliminates fly eggs on the compost piles. We are still evaluating the dosage rate of BAT 506 to determine if it can be adjusted to reduce ammonia concentrations by converting it more rapidly into nitrate.

After 28 days of static composting the volume of the row has shrunk significantly and we are able to turn the row with our existing equipment. But we no longer have to combine rows at this stage of the composting process. The rows are then turned and watered twice and left to continue composting statically for another three weeks. Rows are turned between 6 to 8 times before they are ready for curing at about 3 months. During the active composting phase a row will have been turned between 8 to 10 times versus 20 to 25 times by our old method. This reduction in turning has resulted in significant cost savings (see Table 3 and Figure 2).

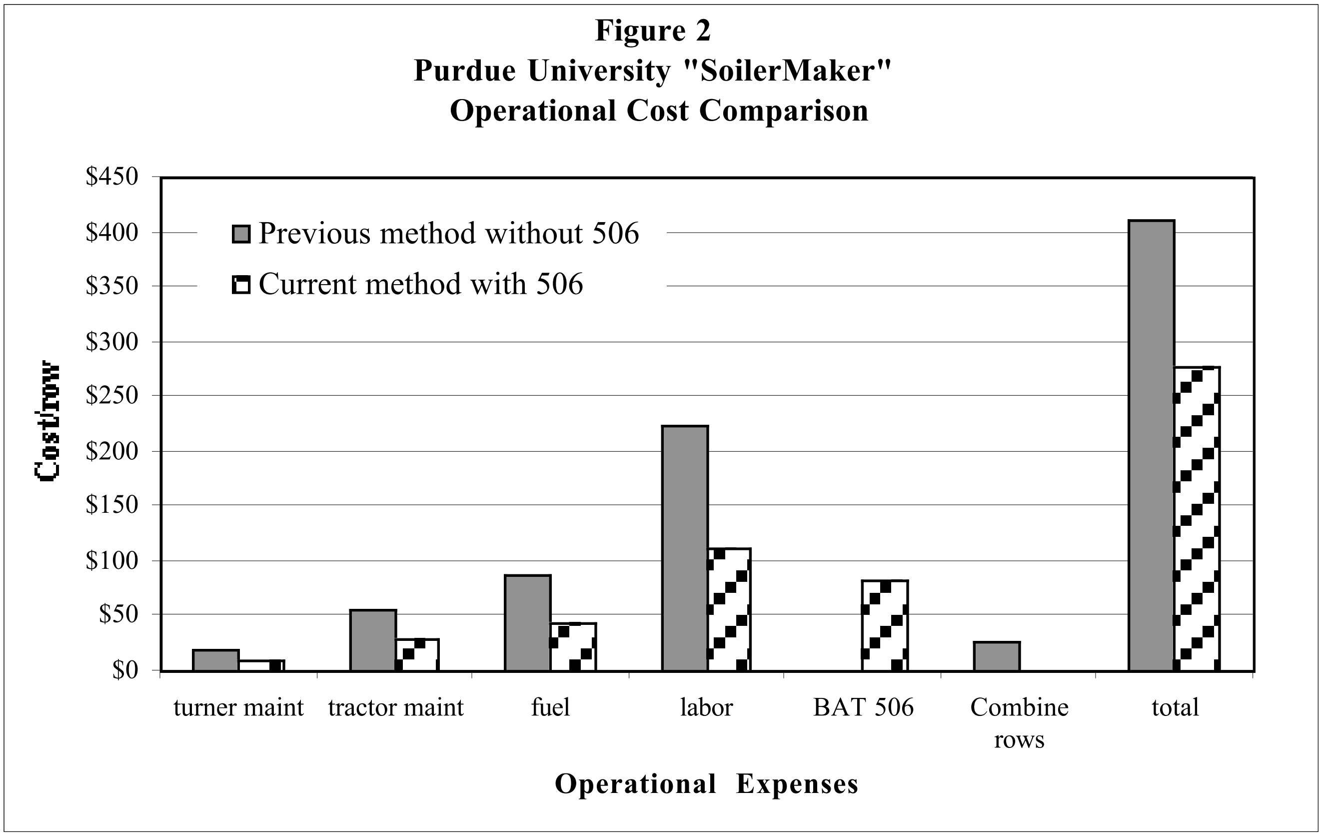
Economic Advantages
Although the most significant advantage of using BAT 506 has been odor reduction, we have found that our new method of composting also reduces operating expenses due to the reduction in row turning (Table 4). We now turn rows an average of 15 times versus 30 row turns using our old methods, a reduction of 50%. It takes an operator about 30 minutes to turn and water a row, 15 fewer turns per row is a reduction of 7.5 hours. It takes operators about 2 hours to combine 2 rows into 1, or 1 additional hour per row. Our fuel, operating, and labor costs per hour are listed in Table 4 and they average \$25.76/hour (not including capital depreciation).

Table 4
Comparison of operating costs when using BAT 506

	Cost/hour	Cost/yd^3	Cost/turn	Cost/row	
Operating Expense		Build new row	30 minutes /turn	Old method (30 turns + combining))	New method (15 turns + 506)
turner maintenance	\$1.25	\$0.00	\$0.63	\$18.75	\$9.38
tractor maintenance	\$3.75	\$0.01	\$1.88	\$56.25	\$28.13
Fuel	\$5.76	\$0.01	\$2.88	\$86.40	\$43.20
labor	\$15.00	\$0.03	\$7.50	\$225.00	\$112.50
BAT 506		\$0.40			\$82.95
Combine 2 rows into 1				\$25.76	
total	\$25.76			\$412	\$276

* includes the extra two turns that occur during initial mixing.

The cost of using BAT 506 is about \$0.40/yd^3 (\$83 per row). However, our operators spend 8.5 fewer hours turning and combining each row for a net savings of about \$136/row. Last year we made 72 new rows. If we continue at the same production rate our total annual savings will be \$9,792 assuming that we have the same production rate. However, since our operators can now spend more time constructing new rows rather than turning old ones so we should actually be able to increase our production. If production remains the same, we expect to see savings due to reduced maintenance and repair on the equipment and reduced down time due to repairs. This year we were down for a total of 30 days due to equipment repairs.



Summary and Conclusions

Purdue University is very pleased with the success of Global Odor Control's products, BAT 506 and BAT 505. The use of BAT 506 and BAT 505 have allowed us to control odors from our composting operation using composting methods that actually save time and money. Since we started incorporating BAT 506 into our compost we have not had a single odor complaint. We are able to utilize fresh biosolids in our composting process and achieve high-quality compost in three to six months without having to screen the end product. We have successfully increased the volume of biosolids (i.e. lower C/N ratio) in our recipe without causing odors, but we have found that this also increases the concentration of nitrogen in our finished product. For our end use, which is very high application rates (as much 500 tons per acre) we want to limit the amount of available nitrogen in our finished product. We also were successful in making compost without woodchips (i.e. lower porosity recipes) without causing odor problems. The use of this product has given us greater flexibility in recipe design while reducing odors.

We believe that the use of this product and the changes in composting methods described in this report, offer a significant improvement for commercial composting operations. Open air, biosolids composting can be done without causing odors. Operations that use windrow turners can realize a significant reduction in operating expenses while maintaining the same volume of production. The use of this product may also allow a greater flexibility in recipe design, one based on end use rather than traditional C:N ratios. We plan to continue exploring the mechanism(s) by which BAT 506 works to prevent odor formation.