Co-processed Poultry Litter and Dewatered Municipal Biosolids: Feasibility as an Alternative Management Approach for Surplus

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Neither poultry litter nor DMB currently have economically sustainable utilization options that are also environmentally sustainable. The purpose of this research is to investigate the appropriateness of blending poultry litter and DMB as a sustainable way to utilize these products, for use in agricultural practices, in a cost efficient manner.

Key Words: poultry industry; waste management; fertilizer; dewatered municipal biosolids

JEL: Q53, Q13, Q16

Introduction

The Ozarks region is a large area used to refer to Northwest Arkansas, Southwest Missouri and Northeast Oklahoma. This area contains the Ozark Mountains with much rugged terrain that does not lend itself well to most cultivation, a major reason that the poultry and cattle industries have large concentrations in the area. Northwest Arkansas in particular has had sustained and major growth in infrastructure and population for the last several years; this boom is expected to continue into the extended future.

Poultry litter and dewatered municipal biosolids are both abundantly available in the Ozarks. They are produced in large quantities and pose a significant potential threat to the environmental stability of the area. Poultry litter, either chicken litter or turkey litter, is a by-product of poultry production. Litter is a combination of bedding materials (rice hulls or wood shaving) and the fecal matter of poultry.

Dewatered municipal biosolids (DMB) is the remaining material in the treatment of wastewater from city treatment plants. These DMB are produced in large quantities in communities all across the Ozarks. Currently, there is no commercially available or viable use for the DMB and it is ultimately destined to be land applied under permit from the state or disposed of at a waste facility or landfill.

Both surplus poultry and DMB have become externalities of everyday life that now require “disposal.” There may actually be alternatives for the use of these products in the agricultural production sector. There are several current possibilities for the use of both these products but there are many questions that must first be addressed. There is no debate about whether there is a problem or that something needs to be done; however, there is much debate on how to address this issue, what that entails and how it should be accomplished. There has been some research on this issue and ideas have been put forth that have proven to be helpful. The problem with most all of these ideas lies in implementation and efficiency. Most notable is the fact that there is currently no cost efficient way to deal with either litter or DMB as waste products or by-products.

Poultry litter is an excellent source of plant nutrients, consisting of about three to four percent nitrogen, two to three percent phosphorus, and two to three percent potassium by weight and generally has twenty-two to thirty percent moisture and carbon content. It is important to keep in mind that these numbers, both nutrient and water content, can vary from region to region and by the actual agricultural practices applied in bird production. Historically, the litter has been land applied on pastures by farmers in the Ozarks. Land application of litter has been going on for more than forty years to increase forage growth. This was done both as a way to utilize the large quantities of litter and to enhance the cattle and hay production industries in the area. A majority of farmers in the area have long relied upon both poultry and cattle operations for their livelihood. The poultry litter is a natural low cost alternative to commercial fertilizer that does not require cash outlays for poultry producers and has been a cash flow source for producers through selling litter to farmers not involved in the poultry industry. To a lesser and more fragmented extent, poultry litter was utilized also by row crop farmers in Oklahoma and Arkansas, most notably in the eastern part of Arkansas. This use has been sporadic and limited at best, partly due to the lack of reliable supplies to that part of the state.

Over the last several years, the poultry industry has become and continues to become extremely concentrated in the Ozarks. This has led to an exponential growth in the volume of litter from the poultry industry. As discussed above, the poultry litter has been land applied at very high rates for many years. The problem is that there is much more phosphorus available in the soil than nitrogen. After all the years of application, the soil has become, in a sense, saturated with phosphorus. In order for the farmers to achieve the proper amounts of nitrogen for production, an over-application of litter which leads to excess phosphorus in the environment would be necessary. This gap between available nitrogen and phosphorus can be attributed to two factors: 1) an imbalance in nitrogen required versus phosphorus required by forage plants of approximately 4:1 and 2) ammonia evaporation which takes nitrogen from the litter and makes it airborne via the ammonia gas escaping, known as denitrification.

Litter applied to cultivated crop land is usually tilled into the soil after being spread, halting the loss of nitrogen by preventing the ammonia from escaping into the air. Poultry litter is over-applied to already saturated areas in the Ozarks there is a leaching of excess nutrients into the ground and surface water of the surrounding areas. Erosion and large rain events further cause run-off into waters which loads them with the nutrients. When water is saturated with excessive nutrients there can be algae blooms, oxygen deprivation, pH imbalances, toxicity and many other harmful results. All of these occurrences are undesirable because they may result in water quality degradation, jeopardizing wildlife in the water and sometimes causing a foul taste or smell of the water for residential uses. It is important to keep in mind there are other causes of these excess nutrients, such as urban runoff, septic tank seepage and point source discharge, but for the purpose of this research the focus will be upon litter and dewater municipal biosolids.

The excess nutrient problem has been amplified by another aspect of life in the Ozarks, growth and development, most notably the boom in the area’s population. Large and rapid population growth in a particular area puts an added strain on the area’s environment. The added strain of particular interest here is that of increased waste, to be more precise the increase in volume of biosolid materials waste.

Poultry growers are now required to develop nutrient management plans. This is supposed to help them and officials to regulate litter application and provide exportation of excess litter. These new practices are due to the recommendations handed down from the Arkansas Soil and Water Conservation Commission, (now the Arkansas Natural Resources Commission). Also, communities in these watersheds were required to discontinue their practices of land applying their municipal DMB. Due to these regulations on waste disposal, the treatment plants have purchased and installed new technology to meet the requirements. The facilities have installed and begun to use what is known as a "belt filter press" which dewaters DMB making it more suitable for shipment out of the area. DMB must meet certain criteria to be deemed land applicable as a class A requirement. This is to ensure no negative health effects from the DMB. There are several ways to accomplish this. One way is through composting where the temperature of the DMB must be maintained at 55 degrees Celsius or higher for no less than three days. The problem with all of the current methods is like those for litter. The nutrients are lost in some amount and the costs are too expensive. In these studies the heating proved to be the cause of the indicator pathogen kills. Currently, dewatered biosolid material is being trucked to a landfill in Eastern Oklahoma, which is a much more expensive prospect than the old method of waste disposal. Added costs are not the only negatives associated with the current disposal scenario. Possibly the most important negative at work here is the loss of nutrients in the DMB by landfill disposal. DMB is high in nutrients much like the poultry litter and could be used in similar manners.

Aside from the issues caused by the excess nutrients and the need for alternatives to their application, there are other issues to be considered. Crop farmers across the region are experiencing decreased margins and rising energy costs, much like poultry and cattle farmers.

One cost that can be addressed and remedied by this experiment is that of fertilizer costs. Increased prices for natural gas, have caused the price of commercial fertilizer to sky rocket. The litter and DMB can be a viable alternative to expensive commercial fertilizer. There are currently 2.3 million acres of cropland available to receive poultry litter and DMB in only seven of the eastern Arkansas counties. An ever increasing portion of this land is “cut” land, land that has been laser or precision leveled. This process leaves surface layers of the land low in organic matter. The use of litter and/or DMB as a fertilizer on this type of ground not only provides nutrients in place of fertilizer, but replaces valuable organic material and microbes lost in the leveling process, a claim that commercial fertilizer cannot make.

Objectives

At this time there is no economically viable solution to the problem discussed at length above. The shipment of loose litter to row croppers’ in eastern Arkansas has proven to be too costly due to transportation, handling, and storage. Also, the use of DMB on cropland is not currently allowed unless tested and found to be negative of certain indicator pathogens. The overall objective of this research is to identify a process whereby excess litter and DMB are transported out of the nutrient saturated areas to eastern Arkansas where crop farmers can use it in an economically efficient manner both for the exporter (poultry industry and municipal waste management) and the importer (crop farmers). Specific objectives of the research are: to determine whether co-processing of poultry litter and DMB can be effectively utilized as a method to eliminate indicator pathogens; this product will be compressed and wrapped in plastic to simulate available baling technology and then stored for various periods. In the initial stage of the experiment the baling process was emulated on a smaller scale to assess the proper chain of events necessary to the successful baling of the nutrients. The purpose of this application was to identify the proper mix of litter and sludge, into a ratio that killed pathogens, had the correct water content, performed best in cost efficiency analysis, and contained the best nutrients possible.

Data and Methods

Data for this research result from experiments conducted under funding from the USEPA and USDOC during several phases of experimentation. The original study on the litter baling process by Mammoth Corporation of Spokane, WA was used as a starting point for this research, which consists of full-scale mixing of different ratios of poultry litter and DMB to determine pathogen kill, nutrient composition and moisture content of each blend, and to determine the optimal mix based upon these parameters. Samples were taken at four time intervals and analyzed by an EPA certified lab at the USDA-ARS station in Fayetteville, AR. Notes were taken during the process (3, 5, 7, and 9 weeks after blending and "packaging") to record any problems/successes observed from the methods used. Lab analyses and notes were jointly compared to give an overall picture of performance. Information regarding the market structure and cost of commercial fertilizer was obtained from the industry.

The overall project itself was quite expansive and took a great deal of planning and monitoring to achieve proper execution. There is a very step by step nature associated with experimentation of this type. This application is no different and there are several levels to the research and experiment. The entire project consisted of a preliminary mixing and compression experiment, full-scale mixing of different ratios and compression experiment, an actual baling of the best mix by the Mammoth baler, and a logistical study to obtain the least cost option for exporting the actual bales. This paper is only concerned with the first phase of this experiment, which include the first two steps mentioned above.

For the second phase of the experiment, the Mammoth litter baler will be assembled and actual baling of the materials will commence. Litter and DMB will be hauled to the site on semi-trailer trucks and dumped in an enclosed shed. Both litter and a mixture of litter and DMB will be baled. The machine, materials, and process will be evaluated for capacity, speed, cost, efficiency, and integrity of finished product (longevity of bales, appearance and smell.) The finished product will then be shipped to eastern Arkansas where a crop yield study will be conducted with the baled product. This information will be used to construct a logistics model for processing and exportation of the baled nutrient where costs, profits, and overall economic efficiency will be evaluated. Although results will not be visited in this paper, they were briefly outlined to provide an overall vision for the entire research initiative.

The preliminary study was conducted to actually test how the materials would behave in a 55 gallon barrel and to perfect the process of mixing and packing for the larger experiment. Eight 55 gallon plastic barrels were used from which the tops were removed. These barrels where then lined with a rigid 15-mil poly bag molded to fit the contours of the plastic barrels. Inside the rigid liners we placed a 4-mil poly bag which was not rigid or molded. This inner bag actually held the materials. Litter was obtained on as-needed basis by pickup truck from various Georges' farms. All litter was positive for E. coli but not for Salmonella. Less than half of George's farms tested positive for Salmonella.

The DMB was received in five-gallon plastic buckets with lids from the Springdale Waste Water Treatment Plant. The DMB was also obtained on an as-needed basis. For the litter and the DMB, samples where taken before the mixing to determine pre-experiment levels of pathogens and nutrients; all were positive for both pathogens of interest. Samples were collected from each batch of blended material, litter and DMB and mixed. Ten samples were taken for the

Poultry Health Diagnostics Lab analysis and four samples were taken for the Poultry Waste Management Lab analysis. All samples were collected in plastic bags which were immediately labeled with: date taken, the study number, the sample number, the type of sample, and the person taking the sample. This study included mixing litter and DMB at one set for one ratio, a mixture of straight litter and water, and litter only. We used four of the barrels to fill with the litter/DMB mixture, one for each for a sample at three, five, seven, and nine weeks. Two barrels were used for the litter/water mix, and two barrels were used for the litter only. Samples were taken from these mixes at the times prescribed above. These samples were taken with a grain probe driven into the bale and then extracted and its contents placed in plastic bags for delivery to the labs to be tested for nutrient content and for any pathogens.

The actual mixing and packing of the barrels was conducted at the Animal Science feed mill adjacent the Abattoir. This site was chosen because of its large open floor plan and the equipment available there. An on-site, electrically powered horizontal feed ration mixer with an extrication spout at the bottom was utilized for the actual mixing of the litter/DMB and the litter/water, and to break-up any large clumps in the litter only material. For the litter/DMB mix, a bucket of DMB was weighed and then added to the machine to be broken up into smaller pieces. At the same time buckets of litter were filled and weighed to meet the correct ratio between the two. Once the litter was weighed, it was added to the mixer where the mixture was allowed to incorporate for several minutes. The pour spout on the bottom was then opened to allow the mixture to be captured in a bucket. The bucket was then dumped in one of the barrels and compacted by a hand tamper. The process repeated until a barrel was full, at which time it would be sealed by twisting the end of the inner bag and securing it with zip ties and duct tape. Each barrel also contained three thermocouple leads one each at the bottom, middle, and top of the barrel. These leads were constructed under the advice and expertise of Dr. Brye (Crop Soil and Environmental Sciences, U of A). Leads are used to take the temperatures of the mixtures inside the bags on a daily basis. Readings in degrees Celsius were taken using a thermocouple reader and were recorded for the nine week study period. The same process was completed for the litter/water mix and for the litter only mix.

In the actual experiment there were some minor modifications. This experiment was conducted with thirty-two barrels of three different ratios litter/DMB mixtures and one litter/water mixture. Eight barrels were mixed for each of the four mixtures. Exact ratios were not disclosed to protect the proprietary process, which is currently in patent disclosure process. Barrels were labeled in sets of two (for replication) corresponding to the sample week and the mixture. The first two barrels are labeled 3.1A and 3.2A, which denotes that these barrels are to be sampled on week three; the A denotes the particular litter/DMB mix. Remaining barrels of that set were labeled 5.1A, 5.2A, 7.1A, 7.2A, 9.1A, and 9.2A for sampling weeks 5, 7, and 9, respectively. This system works the same for the three other mixes which are B, C, and D, which denote the remaining two litter/DMB ratios, and a litter and water mix. For this application the 15 mil rigid drum liners and the 4 mil poly bags were replaced by a single extra tall 55 gallon 8 mil poly bag placed in the barrels. All other aspects of the preliminary experiment remained in tact as pre-tested. Data from the samples were recorded along with the temperatures of the barrels, the thermocouple reader and the ambient air temperature. Temperatures were recorded to track the heating (or lack of heating) trends of the mixtures. Those for mix “B” are shown in Figure1. The samples were also analyzed for the presence of indicator pathogens and the nutrient contents of the products. Macro and micro nutrients essays were conducted for nitrogen, phosphorus, potassium, calcium. Moisture, density, salinity, pH, carbon, sulfur, manganese, selenium, copper, and zinc analysis were also conducted as were tests to quantify the presence and level of E. coli and Salmonella. (Table 2) Mean percentages for nitrogen, phosphorous, potassium, carbon, and water for each mix are shown in Table 1, as are their estimated dollar values. This has all been done for the purpose of finding the most effective and cost efficient way of mixing poultry litter and DMB.

Results

The first thing that was to be established during the course of the pre-trial experiment was the behavior of the litter and DMB as well as the packaging material and equipment used in the process. The litter and DMB mixed well together and made a dark rich soil-like substance that was easily workable. The mixer used was an industrial feed mixer, used in mixing feed rations for livestock. It was unable to handle a full 55 gallon barrel of material, so we found it necessary to combine the respective mixtures in smaller batches. It did take the mixer several minutes to achieve a nice uniform product, this was due to the lumpy nature of both the litter and DMB (the DMB comes in large flat sheets, similar to a ½ inch sheet of chocolate.) After the batches were thoroughly mixed they were quite easy to transfer to the barrels. Once in the barrel, the mixtures were compressed with a hand tamp. This was quite easy, even by hand, and the mixtures formed themselves to the container's shape. As expected, the higher moisture mixtures compressed substantially more than their drier counterparts, but even the low moisture mixtures compressed well. The poly bags held their integrity throughout the course of the experiment and did not allow air to get inside the bag or gases inside the bag to escape. Once the litter/DMB mixtures were inside the bags there were no noticeable objectionable odors with any of the containers. As was the case in the pre-trial mixtures, there was a substantial removal of indicator pathogens within the first three weeks and complete removal of indicator pathogens in all litter/DMB blends by week 5.

The full-scale trial of the in-vessel compression experiment did not utilize the rigid 15-mil barrel liners and the 4 mil poly bags; these were replaced with a single 8 mil poly bag. The full-scale experiment progressed as in the pre-trial in every way. The bags or small bales remained structurally sound, protected against the escape of odors and denied air from entering which kept the mixtures from heating. Temperature variations during the course of the experiment can be attributed to variations in ambient air temperature as shown in Figure 1.

The full-scale experiment resulted in a removal of the indicator pathogens. This was not due to heating, but can be attributed to either gas buildup inside the bags or possibly an anaerobic bacteria buildup (as occurs in silage bales.) Samples were first tested for *Salmonella*. It was found to be 100 percent eliminated from the mixtures as shown in Table 1. This was expected and cannot be attributed to any chemical or physical process inside the bags as *Salmonella* can only live for 72 hours outside a live host. The other indicator pathogen tested for in the samples of the mixtures was *E. coli*, much more hearty and resilient than its counterpart and can survive for extended periods of time without a live host. As shown in Table 2, nearly 90 percent of all samples came back negative for the indicator pathogens of *E. coli* and all were below the threshold of 1,000 colony forming units set as a standard for class A biosolids. The absence of both of these pathogens is extremely important in getting the final mixture approved for use on food crops. All baled mixtures tested would meet these Class A requirements set by the state. This is a very important step to a suitable solution to the excess nutrient problem; other methods of reaching this class A requirement are more lengthy or very costly.

The nutrient content of the samples was also analyzed both in their raw forms (both litter and DMB) and in their mixed ratios. The top of Table 2 shows the individual materials and the mixtures' moisture level as a percent and N, P, K, Ca and C as pounds per ton of material. The bottom of Table 2 shows the monetary value for N, P, K and Ca in dollars per ton of material. In the top portion of Table 2 there is also a column containing carbon in pounds per ton. This is an important aspect of the mixtures and their overall performance on the land and crops. It is important to look at carbon as an indicator or measurer of organic matter which is a benefit to the use of litter and DMB. The mixtures researched can replace valuable organic matter that has been lost to farming practices or to laser leveling. As discussed previously in the paper, this is something that the commercial fertilize cannot claim. There was not a dollar value given for the carbon because there is no current market for carbon and, therefore, no way to quantify its monetary value.

Table 2 supports the assertion that packaging does in fact trap ammonia gas in the bags which helps the mixture retain nearly all of its nitrogen. After review of all research and experimental data it has been concluded that the optimal mix of the litter/DMB is ratio B. This mixture seemed to have the best texture and was most lacking in odor at the end of the experiment. It did not clump when removed from the bag which means that it would spread easily from a fertilizer buggy or litter truck. This particular mixture is also the most economically valuable based on the amount of nutrients present.

Transportation costs are also substantially reduced with litter in a baled form. This cost reduction comes from the bales being hauled on a flatbed trailer instead of a specialized walking floor trailer specifically for litter or DMB. A flatbed trailer costs less both to own and operate, and it has more room for hauling product. Also the flatbed trailers increase the opportunity for a backhaul load, making them more versatile and saving both the exporter and importer money. Costs to ship litter/DMB in its baled form have been estimated to be as a low as $2 per mile. (Goodwin)

Conclusion

Excess nutrients resulting from concentrated and confined animal production and municipal sewage treatment waste is a growing problem in the Ozarks as it is in many other areas of the South. A sustainable and economically efficient remedy must be found in order to help the environment and the economy in the Ozarks and the rural South. Baling litter and DMB may be an answer. It can provide economic profits for the exporter and valuable nutrients and input savings for the importer while removing potentially degrading substances from the environment. Under current practices the nutrients, organic matter, and value of DMB is being lost to landfills. There are over 60,000 tons of DMB produced annually and over 100,000 tons of surplus poultry litter in the Illinois River Watershed. That translates into approximately $5,800,000 worth of litter and $3,660,000 worth of DMB in value being lost every year. This material could be used as a nutrient for crop land in the Delta region and provide an economic boost for both the Delta and the Ozarks. This could be another negative externality turned positive and one more step toward sustainability in the agricultural sector.

Figure 1.

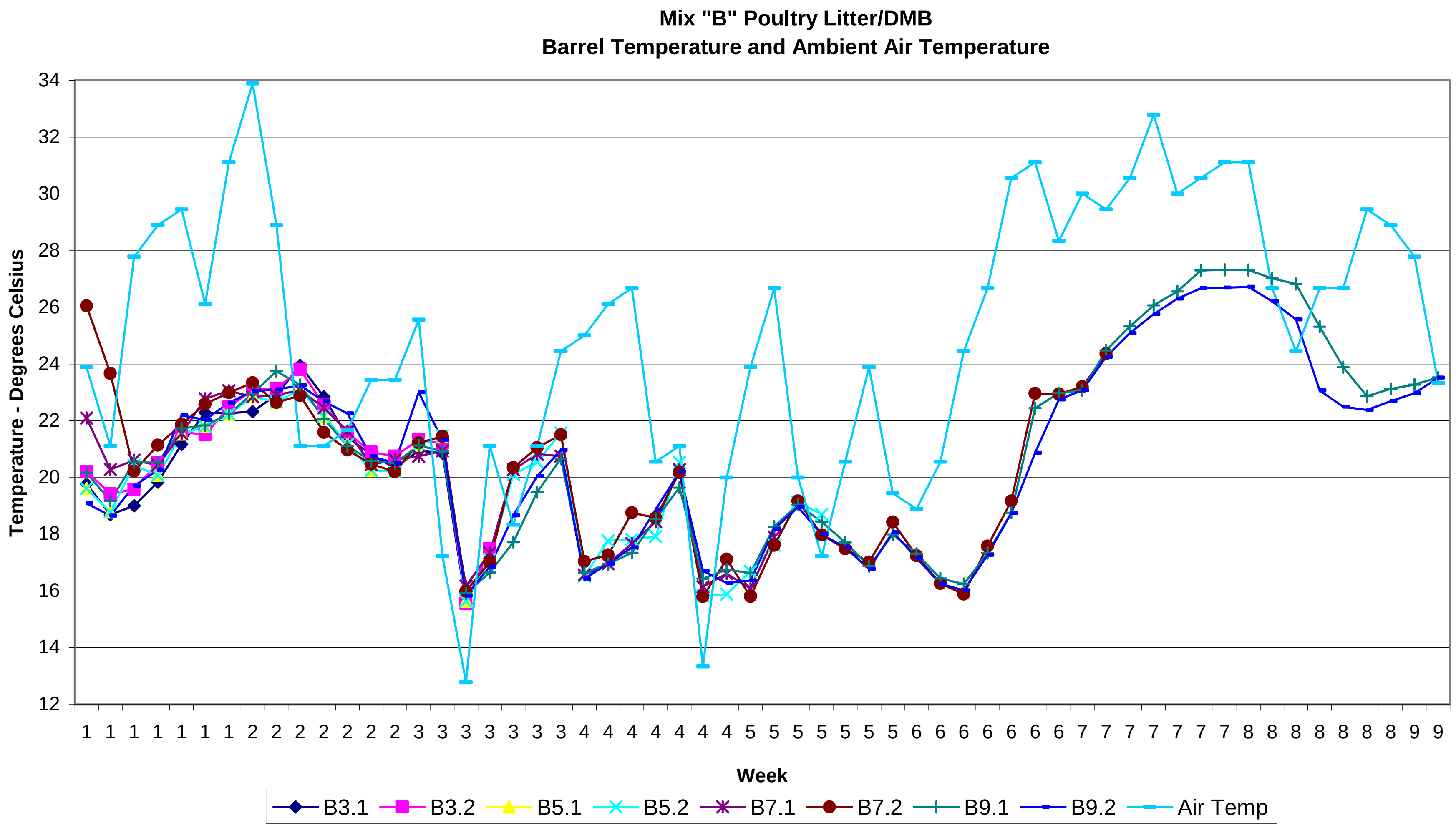
Mix "B" Poultry Litter/DMB
Barrel Temperature and Ambient Air Temperature
Temperature - Degrees Celsius
34
32
30
28
26
24
22
20
18
16
14
12
1 1 1 1 1 1 1 2 2 2 2 2 2 2 3 3 3 3 3 3 3 4 4 4 4 4 4 4 5 5 5 5 5 5 5 6 6 6 6 6 6 6 7 7 7 7 7 7 7 8 8 8 8 8 8 8 9 9
Week
B3.1
B3.2
B5.1
B5.2
B7.1
B7.2
B9.1
B9.2
Air Temp

Table 1.

EPA Indicator Pathogen Results Percentages Table									
Mixture	A	B	C	D		A	B	C	D
	Salmonella	Salmonella	Salmonella	Salmonella		E. Coli	E. Coli	E. Coli	E. Coli
Barrel									
3.1	100%	100%	100%	100%		80%	100%	100%	90%
3.2	100%	100%	100%	100%		90%	100%	100%	100%
5.1	100%	100%	100%	100%		90%	90%	30%	100%
5.2	100%	100%	100%	100%		100%	30%	80%	70%
7.1	100%	100%	100%	100%		100%	100%	100%	100%
7.2	100%	100%	100%	100%		40%	100%	100%	100%
9.1	100%	100%	100%	100%		100%	90%	100%	100%
9.2	100%	100%	100%	100%		90%	90%	100%	100%
			Total	300 neg.				Total	286 neg.
				0 pos.					34 pos.
				100%					89.40%

All percentages are the percent of samples that were negative for indicator pathogens
A,B,C,D indicates the mix and the numbers along the left column indicate the barrel and week sampled
All litter and DMB were positive for E. Coli at the beginning of the experiment
All DMB were positive for Salmonella at the beginning of the experiment
Most litter samples were positive for Salmonella at the beginning of the experiment

Table 2.

EPA Nutrient Results Table and Corresponding Value Based Upon Commercial Fertilizer Prices

Experiment	Material	% H_2O	N lbs/ton	P lbs/ton	K lbs/ton	Ca lbs/ton	C lbs/ton
Pre-Trial	Raw Litter	26%	65.30	66.70	61.32	44.60	555.00
Pre-Trial	Biosolid	82%	26.70	151.80	24.24	25.70	141.90
A	DWBS-PL	46%	56.40	77.97	64.44	50.10	397.10
B	DWBS-PL	40%	59.30	88.32	68.40	55.90	444.50
C	DWBS-PL	32%	66.10	62.79	62.76	44.20	488.10
D	PL & H2O	40%	60.60	63.94	66.12	42.80	455.30

		N $/ton	P $/ton	K $/ton	Ca $/ton	Total Value N-P-K $/ton	Total Value N-P-K-CA $/ton
Pre-Trial	Raw Litter	24.84	20.01	12.88	0.45	57.73	58.18
Pre-Trial	Biosolid	10.16	45.54	5.09	0.26	60.79	61.05
A	DWBS-PL	21.46	23.39	13.53	0.50	58.38	58.88
B	DWBS-PL	22.56	26.50	14.36	0.56	63.42	63.98
C	DWBS-PL	25.15	18.84	13.18	0.44	57.17	57.61
D	PL & Water	23.05	19.18	13.89	0.43	56.12	56.55

N=Nitrogen, P=Phosphorus, K=Potassium, Ca=Calcium, C=Carbon
DWBS=Dewatered Municipal Biosolids (DMB), PL=Poultry Litter

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