HALL COUNTY WAXED CORRUGATED CARDBOARD COMPOSTING PILOT PROJECT

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INTRODUCTION

Hall County is located in Northeast Georgia and encompasses 392 square miles and a population of approximately 113,000. Gainesville, the county seat, is situated 52 miles northeast of Atlanta. The County is home to Lake Sidney Lanier, a 38,000-acre lake built by the U.S. Army Corps of Engineers. The 607-mile shoreline provides recreational activities for over 16 million visitors annually and is of vital economic importance to the area. Lake Lanier served as the canoe/sprint kayak site for the 1996 Summer Olympics.

Agribusiness has always been the cornerstone of Hall County's economy. With Hall County leading the way, Georgia has been one of the top poultry producing states in the nation since 1957. Other leading products are corn, sorghum, soybeans, wheat, rye, oats, pulpwood, dairy and beef cattle, granite and limestone. As of August 1993, there were 871 farmers located in Hall County with a total of 10,200 harvested acres. Hall County's industrial base includes poultry processing and equipment, commercial printing, window and door components, soft drink bottlers, paint, furniture, textiles, and automotive components.

There are several large sources of waxed corrugated cardboard (WCC) in the waste stream. Locally, these include (in order of importance) the poultry industry, grocery stores and restaurants. It is a problem material for waste management. Technically, it can be recycled. However, due to increased energy requirements, higher processing costs and availability of cheaper and more suitable feedstocks, it cannot be recycled practically. It may also make a suitable feedstock for energy recovery. A search of the literature suggested it may also be composted.

WCC is high in carbon and can absorb moisture once shredded and mixed with other materials. An existing waste stream from the poultry industry is the poultry manures and litter which can form an excellent nitrogen amendment. The combination of these two waste streams that have mutually compatible characteristics can be effectively used in composting to produce a quality end product.

Not much is known of the feasibility of this concept and the ability to perform composting in large scale. The evaluation of the feasibility of composting as a tool to treat these wastes and its demonstration in full scale is the focus of this project.

PROJECT OVERVIEW

To plan this project, a work group consisting of a subcommittee of the Hall County Comprehensive Solid Waste Management Plan Implementation Committee, representatives from Georgia Mountains Regional Development Center, Chestatee-Chattahoochee Resource Conservation & Development, Georgia Poultry Federation, allied poultry industries, UGA and grocers, was assembled. The work group began meeting in 1995 and met throughout the project planning and implementation phases to provide input into project design and project oversight.

As identified by Hall County's Comprehensive Solid Waste Management Plan, seven percent of the waste stream was estimated to be waxed corrugated, representing the largest single waste stream component yet to be subject to reduction activities. This amounts to an estimated 7,000 tons annually in Hall County alone. Currently, there is no option other than disposal for this material.

The subcommittee met first to explore options for dealing with WCC. Recycling did not seem feasible. The only time WCC might be in demand as a feedstock by paper mills would be in times of high prices and shortages of corrugated cardboard. Since these conditions could not be relied upon, recycling was dropped from further consideration. The energy recovery option was also considered, but due to the distance from our area to facilities equipped to utilize this type of material, freight charges proved prohibitive. Use of ground, WCC was explored for possible use as layer bedding or cellulose product. The high friction caused by the material in the processing equipment nearly caused a fire. Source reduction was also considered but was felt to be too difficult to implement due to the many, varied sources of the material and the health and sanitation aspects of reusable containers.

Composting was chosen as an option warranting further exploration because:

1. It can be a low tech approach that can be done locally;
2. Markets for the finished product may be developed locally;
3. Organics contamination is not problematic;
4. Poultry manure is available in abundance as a nitrogen source; and
5. It may solve two problems at once-- beneficial utilization of waxed corrugated cardboard and poultry litter (manure).

The goal of the pilot project was to amass 40 tons of WCC in advance of composting. Various poultry processing firms were contacted to obtain the material. There was at first some delay in getting the material from processors. As with any new program, adjustments were needed in the way the material was being handled at the point of generation. After this inertia was overcome, sufficient material was quickly gathered. Tractor-trailers were used by generators to haul the material to the Hall County Recycling Center in Gainesville. Boxes were flattened and placed on pallets for ease in off loading using a forklift. After the material was unloaded, it was baled and stacked outside on a paved surface.

The pilot project was comprised of two distinct parts-- controlled laboratory and windrow composting.

THE POULTRY INDUSTRY

The project is of special importance to the area. The largest employer in the area is the poultry industry, which generates WCC from further processing operations, such as deboning, breading, etc. WCC is used internally as intermediate containers during processing and as shipping containers for finished product. They are useful due to their ability to maintain strength under high moisture conditions.

A considerable percentage of waxed corrugated is expected to be contaminated. In poultry processing, the material may come in contact with poultry processing liquids, blood and poultry itself. Grocery stores may discard waxed corrugated boxes with vegetable matter from preparation for store presentation as well as outdated produce. This mixture could itself be composted, but will not be part of this pilot study, as this has been studied previously and results published in the literature. The pilot project investigated composting of WCC with both broiler litter and layer manure. As Table 1 shows, broiler litter tends to have lower moisture and lower nitrogen due to being mixed with wood shavings in poultry houses. Layer litter is higher in moisture and nitrogen.

Poultry litter disposal or utilization through land application is expected to become increasingly difficult, given the rate of residential growth and reduction in open space. This can be dealt with by composting with sufficient carbon material. It is believed the demand for carbon containing material can be met by waxed corrugated cardboard. In this way, a disposal alternative for waxed corrugated will be provided.

Table 1. Properties of materials used in the composting trials. Values were either measured or estimated from the literature.

Material	Moisture, %	Carbon, %	Nitrogen, %	Density, lbs/yd^3
Cardboard - shredded [1]	6.2	55.1	0.1	251
Layer Manure - fresh[2]	64	8	6	1300
Layer Manure - old	64	6	2	-
Broiler Litter	26	18	3.5	750

[1]Measured ash percentage was 091% (ASTM method for determination of volatiles and ash content of organics). The carbon content was measured and nitrogen content was taken from the literature values of cardboard materials. Typical lignin content of corrugated cardboard is known to be about 12. 9 % and the biodegradable fraction is 47 % (Tchobanoglous et. al., 1993).
[2] All data relating to the manure and litter was provided by Mr. J. Sargent.

CONTROLLED LABORATORY TESTING

OBJECTIVES

The objective of this project was to evaluate the compostabiltiy of old waxed corrugated cardboard from the poultry industry, using poultry manures and broiler litter as nitrogen amendments. Initial laboratory screening identified the mixes to use and characterized the products of composting, as shown in Table 1. A full scale composting demonstration was to be performed based on the laboratory study and scale up factors and products were to be evaluated.

MATERIALS AND METHODS

The WCC was shredded using the tub grinder at the windrow site and mixed with two nitrogen sources--broiler litter and layer manure. Two levels of application of nitrogen amendments were evaluated, namely, a high rate and low rate. The effect of addition of a compost starter mix was also evaluated. These tests were performed August 28 to September 30, 1996. The use of poultry manure was found to be superior to the use of broiler litter as an amendment. Although poultry manure did not mix well in the test vessels, the available nitrogen was higher and aeration of the mixture was easier. It is possible to use high rates of poultry manure in the mixes and reach a stable product in 60 days.

Composting was performed in 30 gallon steel drums insulated with 2 inches of Styrofoam. Insulation minimizes the conductive heat loss from the vessel thereby simulating behavior within a large compost pile. Temperature of the material in the vessel was monitored at three locations (6 inches from the surface, middle of the drum and 6 inches from the bottom) using T-type thermocouples. The vessels were aerated using a temperature feedback control with an adjustable set point that was set at a temperature of 55°C. When the compost temperature exceeded the setpoint, the fans would operate at a high flow rate resulting in cooling of the materials. Airflow rates were set at a value of 1.84 cfm in all of the barrels.

The composting test vessels were emptied at each mixing and sampling event (approximately once a week) and the material mixed in a large plastic drum. The material was rewet when necessary to raise the moisture content to approximately 50% (wb). Two representative samples were removed, one for moisture and volatile solids analysis and the second sample for stability/phytotoxicity analysis. Moisture was evaluated by drying in the oven at 105°C for 24 hours. The sample, after complete drying, was ground fine and ashed at 550°C for 6 hours to estimate the volatile solids and ash content. A portion of the ground sample was retained in storage for future chemical and nutrient analysis. The sample for stability/phytotoxicity testing was frozen and analysis was performed at the end of the experimental period.

Table 2. Mixes used

Treatment # Barrel #	Mix	Percentage Amendment in mix (volume basis)	Moisture Adjustment
1	20 gal Layer manure 30 gal WCC	40% manure	moisture added
2	20 gal Broiler litter 30 gal WCC	40% litter	moisture added
3	10 gal Layer manure 30 gal WCC	25% manure	moisture added
4	10 gal Broiler litter 30 gal WCC	25% litter	moisture added
5	20 gal Layer manure 30 gal WCC with compost starter	40% manure with starter	moisture + starter
6	20 gal Broiler litter 30 gal WCC with compost starter	40% litter with starter	moisture + starter

Respiration index is a reliable measure of the stability of the compost and is reported as the microbial respiration rate in mg(oxygen)/g(dry matter)/hr. Higher availability of nutrients result in higher respiration rates and therefore the material is considered unstable. The quantitative respirometry procedure used in this project was described by Iannoti et al. (1993). In brief, the samples were allowed to reach room temperature, sample preparation was performed, and the samples were allowed to incubate at 37°C for 16 to 24 hours. Sample preparation included screening for fines (< 9.1 mm) and adjusting to a 50% moisture content. After the standardization of the sample and 16 to 24 hours incubation, the microbial populations would have reached a high level of activity that is limited only by the substrate availability. A standard weight of 60 g (dry weight) of each incubated sample was now placed in a 500 ml flask which was placed in a water bath at 37°C and aerated for a one hour period. Following aeration the flask was capped with a dissolved oxygen measuring probe. As there was no air gap between the probe and the neck of the flask, the probe measured the oxygen concentration within the flask which reduced with time due to microbial consumption of oxygen. The oxygen uptake rate was calculated based on the measured oxygen concentration profile for a one hour period, the volume of the flask and the weight of the sample. Generally a respiration index of < 0.15 mg(oxygen)/g(VS)/hr is considered as stable levels for most compost (Barberis and Nappi, 1995).

The effectiveness of using a compost starter was evaluated (see Table 2). Comparison was made by using the compost starter mix as recommended on two treatments and comparing to two identical treatments without the starter. The compost starter used was the B.D. compost starter sold by the Pfeiffer Foundation, Inc. of Spring Valley NY. The starter came in the form of a powder and was mixed in 1 gallon of de-ionized distilled water at the recommended rate of 2 grams/100 lb. of compost. The mixture of compost starter with de-ionized water was kept in the laboratory at room temperature overnight and applied to the compost the following morning while mixing the compost thoroughly.

Interstitial oxygen concentration and quantitative odor evaluation were performed. A four feet stainless steel air sampling probe was inserted into the compost bed and the interstitial air was pumped into a field oxygen meter (Teledyne Brown Inc.) at a flow rate of 0.6 lpm. The sample pump was allowed to run for two minutes in order to clear the sampling lines and stabilize the meter. Oxygen concentration measurements were recorded at the end of the two minute period. An odor monitor (Sensidyne Inc.) was used to measure the odor intensity of the exit gas from the headspace. A gas sampling probe was inserted into the top 1 inch of the compost and gas was pumped through the sample pump. In order to ensure the flushing of the gases within the compost matrix, the composting vessels were aerated for one minute prior to sampling and the highest odor level in a two minute interval was

recorded. Typically the measured value reached a maximum and remained at the maximum reading for the whole two minute period.

TEMPERATURE PROFILES AND RATE OF SELF HEATING

Comparing the temperature profiles, the highest activity was found in T2 which sustained temperatures above 50 °C for most of the 30 days. Treatment 6, which was identical to T2 but had the compost starter added, had lower temperatures throughout the composting cycle. In treatment 1, which was the manure treatment, the high rate of composting occurred for the first 15 days (until the end of the first turn), thereafter the temperature was below 40 °C for both the levels of layer application (T1, T3 and T5). Both the litter treatments T3 and T4 were active for longer periods of time.

It was noticed that the pressure drop across the compost was higher in the litter treatments compared with the manure treatments. At the start of composting, the manure treatments exhibited pressure drops in the range of 0.08-0.25 inch(water)/ft(compost) and the litter treatments 0.12-0.64 inch/ft. Towards the end of composting, the pressure drops had reduced to 0.01-0.07 inch/ft for manure mixes and 0.09-0.30 inch/ft for litter mixes. This indicates higher energy cost if forced aeration was used, and less airflow under natural ventilation conditions.

VOLATILE SOLIDS LOSS DURING COMPOSTING

The samples removed at the start and at each mixing operation were dried and ashed to determine dry matter content and volatile solids content. Drying was done in an oven at 105 °C for 24 hours and ashing of the dried samples was performed by placing the samples in a muffle furnace at 550°C for 6 to 6.5 hours.

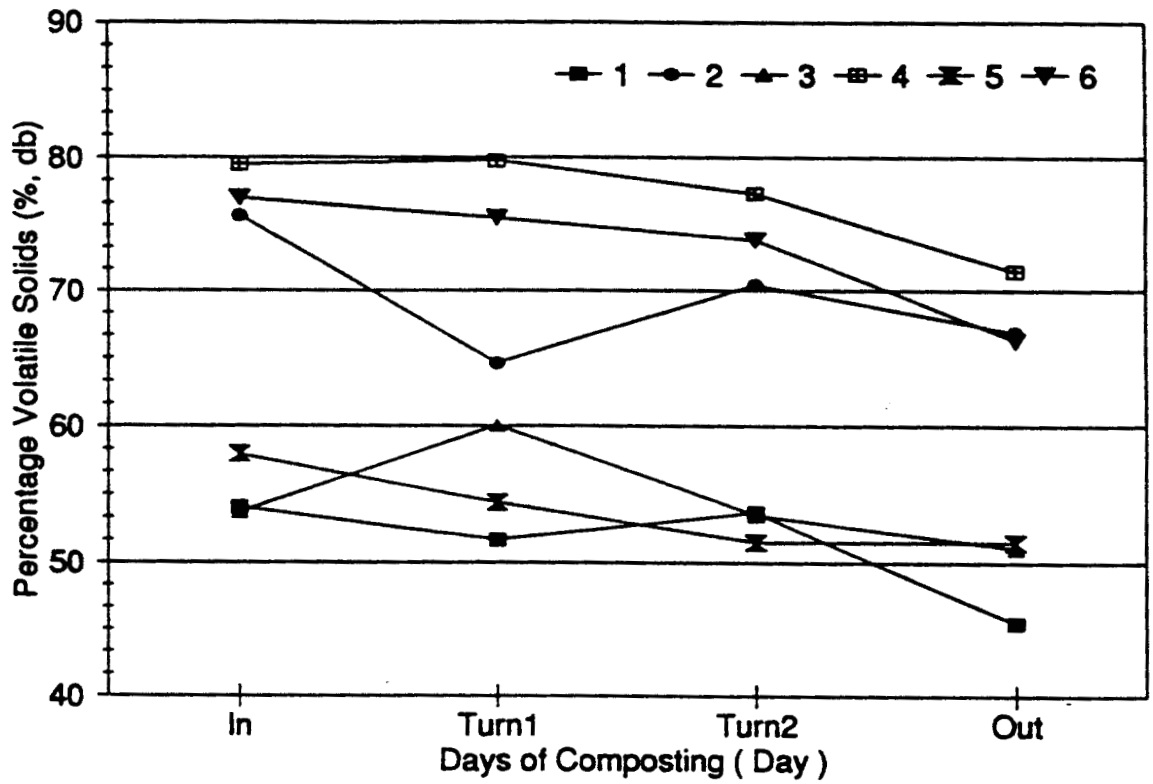

Figure 1. Degradation of volatile solids during composting. Legend indicates numbers 1-6 representing treatments 1-6.

The measurements and changes of volatile solids during composting are shown in Figure 1. It was seen that all of the treatments resulted in reductions ranging from 7 to 11% absolute. Although individual variations existed, broiler litter treatments showed marginally higher total degradation. This result indicates that although higher manure content resulted in more available nitrogen, total degradation was reduced as less cardboard was available. The physical nature of the manure also affected degradation by the clumping and non-homogeneous mix described earlier. A more thorough mixing procedure at the start and during composting may alleviate this problem. The degradation was comparable in all treatments.

INTERSTITIAL OXYGEN CONCENTRATIONS

Except for the first few days all of the treatments had sufficient oxygen during composting. In the first 57 days biological activity was high and oxygen concentrations below 5% were reached when the fan was not operating even for a small period of time. Treatment 2 was the most reactive based on oxygen demand. This may also be due to the lesser air void space in the bed, which also results in higher pressure drops. On days 6, 13 and 20 the oxygen levels were below 5%, which is considered the ceiling for anaerobic activity. Similar situations occurred in treatment 4 and 6 indicating the difficulty in oxygenating these piles due to the higher pressure drops, lower porosity and potential non-uniform airflows. Treatments 1, 3 and 5 stayed above anaerobic levels throughout the duration of composting. The low oxygen concentrations during the first few days indicate a necessity for agitation or steady aeration during this period.

AMMONIA RELEASE AND ODOR ISSUES

An odor monitor (Sensidyne Inc.) made it possible to obtain quantitative measurements of odor released based on a butanol concentration scale. These are shown in Figure 2. The odor intensity data was collected only from day 13 to the end of composting. The odor levels were closely correlated with oxygen levels inside the barrel. The broiler litter treatment 2 and 6 were the high odor producers. As the materials reached the end of composting, a more earthy odor was perceived.

EFFECT OF COMPOST STARTER ADDITION

An evaluation of the use of a compost starter was performed by adding two treatments (T5 and T6) that were identical to T1 and T2 but with the addition of the compost starter. In T1 and 2 an equivalent quantity of water with no compost starter was added to compensate for the addition of moisture. Based on an analysis of temperature profiles, volatile solids destruction and odor released, it can be concluded that the compost starter did not have any observable effect on the process. Treatments 1, 2 were compared with 5, 6 for these interpretations. The results of the tests were identical. Additional replicated studies will be necessary to completely rule out any other possibility.

CARBON LOSS AND C/N RATIO

In all of the mixes the initial C/N ratios were in the range of 18 to 26. Generally, higher levels up to 30 are considered acceptable in composting. All of the treatments reached levels of 11 to 17 at the end of composting. This renders the compost more suitable for application to soils without resulting in a N depletion in soils when compost is applied. Highest carbon loss was found in treatment T3 which reduced from an initial of about 39% to a final carbon concentration of 27%. The corresponding C/N ratio was found to be 11. This shows that the 25% manure amended treatment is possibly a better mix when carbon degradation (cardboard disposal) is the focus.

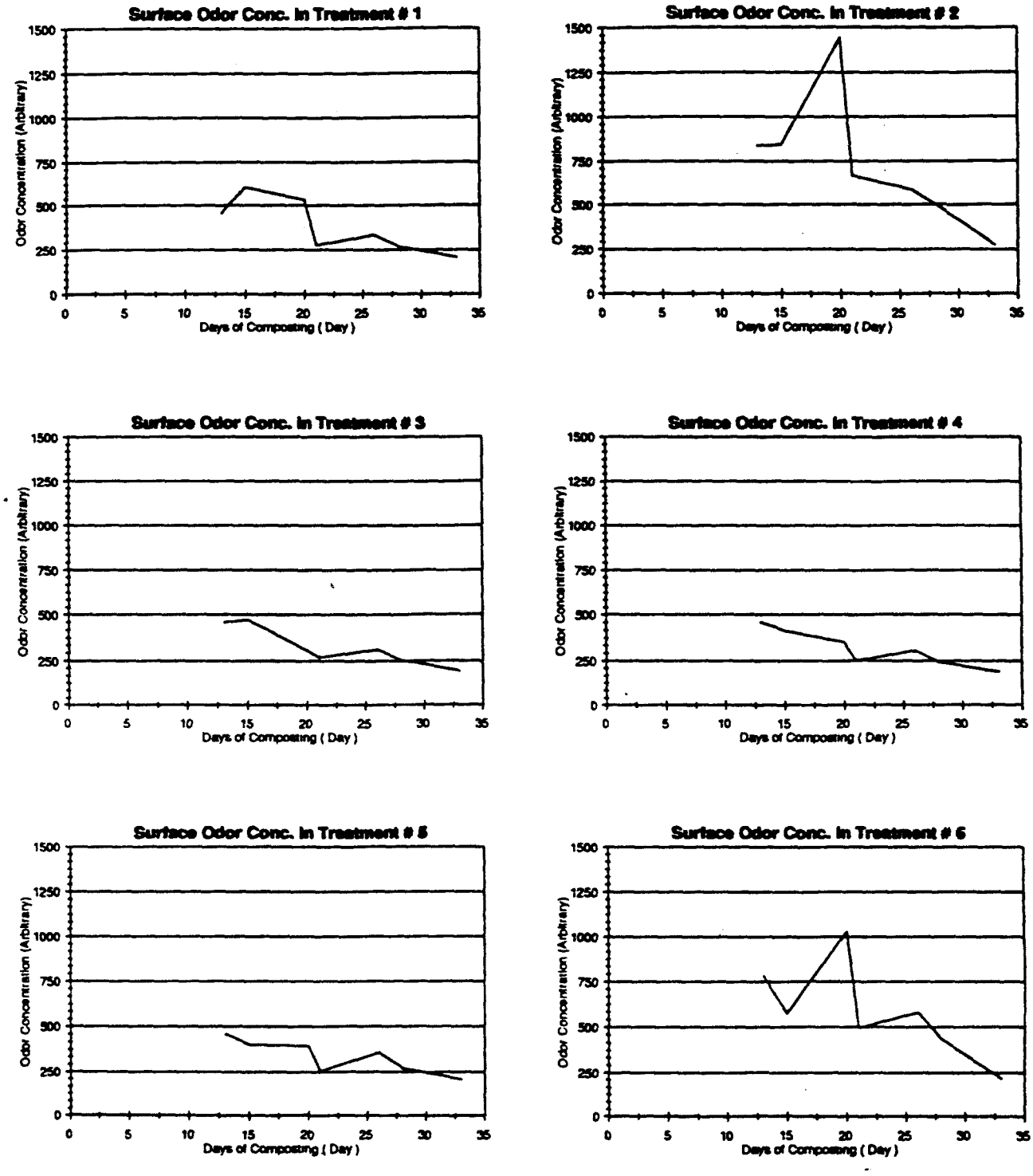

Figure 2. Surface odor concentrations in the test vessels during the composting of waxed corrugated cardboard. The six treatments are respectively on a volume basis 40% manure, 40% litter, 25% manure, 25% litter, 40% manure with compost starter, and 40% litter with compost starter.

Table 3. Plasma emission spectrograph results of final product from composting of mixes of waxed corrugated cardboard with poultry manure and litter. Refer to Table 2 for mix ratios.

Species[1,2] (EPA - Limits)	T1	T2	T3	T4	T5	T6
Metals						
As (4.1)	1.8-2.2	14.4-15.4	1.7	10.4-10.5	1.8	15.2-15.9
Cd (39)	0.19-0.16	0.27-0.34	0.17-0.20	0.3-0.35	0.06-0.18	0.3-0.37
Cr (1200)	1.9	2.5-2.6	1.7-1.8	2.4-2.5	1.8	2.6-2.7
Cu (1500)	1.8	33-36	2.0-2.2	15.5-16.2	1.5-1.7	32.9-34.4
Pb (300)	0.7-1.0	1.3	1.0	1.3-1.5	0.7-1.0	1.3-1.4
Ni (420)	2.5-2.7	2.0-2.1	2.0-2.4	1.6-1.7	3.3-3.4	2.1-2.3
Zn (2800)	4.0-8.9	110-140	6.1-10.5	89.9-92.7	4.4-6.3	103-122.5
Macro nutrients						
N	21800-23700	18400-19600	23300-25500	21900-24800	24900-25400	23100-26400
P	6493-7730	10486-11085	6464-6953	7808-8426	6531-8609	11031-11955
K	22205-25885	21073-23319	19423-20204	18789-18898	25011-25172	23109-24096
Ca	5352-9704	11285-11380	9495-10424	8824-8990	6018-9359	10574-11365
Mg	1160-1270	1176-1196	1134-1143	1161-1188	1170-1219	1215-1232
Na	6540-7614	5679-6205	6182-6462	6071-6089	7242-7249	6208-6260
Se	3.6-4.0	4.2-4.7	3.8-4.1	4.8-5.0	3.8-3.9	4.5-4.8
Mo	0.2-0.24	0.43-0.53	0.14-0.20	0.38	0.14-0.17	0.51
Micro nutrients						
Fe	1.6-3.5	43.3-47.3	3.0-4.1	26.8-27.4	1.5-2.3	44.0-51.4
Mn	21.3-43.1	226.9-234.4	32.0-44.6	209.8-218.4	27.4-37.4	236.7-241.0
B	25.8-29.6	33.8-36.6	24.4-25.5	42.4 -44.3	26.3-27.7	38.6
Co	0.13-0.16	0.29-0.34	0.11-0.12	0.22-0.24	0.13-0.14	0.23-0.29

[1]All units are in ppm (by weight).
[2] Results indicate total species by dry weight fraction. This does not necessarily imply plant available, microbe available or leachable fractions.

LABORATORY CONCLUSIONS

The results of this project clearly indicate that manure is a superior amendment in the composting of old waxed corrugated cardboard. The final nutrient and metals concentrations are presented in Table 3.

The following are some of the important reasons and some additional conclusions.

1. Manure amended mixes reached higher levels of stability at the end of the high rate composting.

2. Manure amended mixes were found to be mature, based on the 70% germination index, at the end of the curing phase. Curing of at least 30 days is required for these composts.

3. Manure amended mixes exhibited lower pressure drops at the same air flow rates. This suggests higher porosity and more aeration. This factor is also related to the fact that these mixes did not become anaerobic during composting and had relatively less odors generated.

4. Manure treatments had a higher rate of degradation and showed less activity after the 14th day of high rate composting. This suggests that the materials can possibly be removed from high rate composting and transferred to curing at this time.

5. Good mixing is absolutely essential with manure mixes. These mixes showed a very high tendency for clumping and this results in poor composting. Broiler litter amended mixes were more homogeneous; however, the higher packing factor resulted in lesser porosity and higher pressure drops in these mixes.

6. Final nutrient concentrations indicated that the product had a NPK equivalent of a 2:1:2 fertilizer. The plant availability of these nutrients is not known and further plant growth tests are required.

7. The broiler litter treatments had higher concentrations of metals leading to a product that had a relatively higher metal concentration.

8. Boron was rather high in all of the products. A threshold of 50 ppm can become dangerous to certain plants. However, at less than 50ppm, compost may be applied at normal application rates with low to no concern.

9. The use of the compost starter showed no benefit to the composting process. Further evaluation has to be performed to rule out any other possibility.

10. These experiments were performed with composting mixes in the moisture range of 50-55%. Higher moisture levels need to be used, and an evaluation of this is required in full scale testing.

WINDROW COMPOSTING

The windrow portion of the study was carried out by Sargent Nutrients, Inc., a long standing composting firm in north Georgia. The location chosen was the Lee Arrendale Correctional Institute in Habersham County. This seemed a natural choice since all the necessary equipment would be at this site due to the startup of the Institute's own food waste composting program. The same contractor would be providing oversight on the Institute's project startup under the auspices of Chestatee-Chattahoochee Resource Conservation and Development.

In advance of start up at the site, the baled WCC was loaded onto tractor-trailers for transport to the composting site. Weights were recorded for each load leaving the recycling center. A total of 75,120 pounds was shipped, slightly below the goal of 40 tons. Of the 40 tons hauled to the site, approximately 30 tons were used in our project. The remainder was used in the Institute's program. Approximately 5 tons of broiler litter and 5 tons of hen manure were also hauled to the Lee Arrendale Correctional Institute composting site. The approximate ratio (by weight) of WCC to poultry litter was 3:1 or 75% WCC to 25% litter, approximating that used in laboratory treatments 3 and 4.

A DuraTech 8 Tub Grinder was used to preprocess the WCC. Problems occurred with the tub sensor for the first two days, resulting in lost time. It was felt the material would process better if the bales were cut apart and allowed to soak up moisture (rain). Through trial and error, it was discovered that the material processes much better when dry and even better when mixed with poultry litter. After shredding, the cardboard handled very well. Most pieces were in the two to three inch range. The DuraTech did a good job after fine tuning our methods. Other machinery might be better suited to the task on a daily basis, however. After grinding the WCC, a windrow of poultry litter and WCC was mixed to an approximate C:N ratio of 30 to 1. Hen manure and waxed cardboard was also mixed together with the same ratio.

Table 4. WCC windrow composting monitoring

Date	Weather	Moisture	Odor	Broiler Litter 30'	Broiler Litter 60'	Hen Manure 90'	Hen Manure 120'
09/09/96	SUNNY						
09/16/96	SUNNY	35%	MILD	150°	144°	154°	146°
09/19/96	SUNNY 88 °	35%	MILD	134°	138°	140°	138°
09/20/96	SUNNY 88°	35%	MILD	138°	144°	146°	148°
09/23/96	SUNNY 86 °	45%	N/A	140°	150°	144°	140°
09/25/96	SUNNY 86°	45%	MUSTY	144°	146°	146°	142°
09/27/96	RAIN 72°						
10/01/96	CLOUDY 62°	45%	MUSTY	130°	136°	136°	136°
10/03/96	SUNNY 76°	45%	MUSTY	138°	134°	134°	140°

The windrow was set September 7, 1997 into one row--broiler litter and cardboard at one end and hen manure and cardboard at the other. Upon formation of the windrow, it was decided the moisture level was too low and needed adjusted. Moisture was added using a tanker truck and fire hose. Approximately 2,400 gallons of water were added on this and subsequent occasions on September 24 and October 24.

Temperature and turning schedules were established. A Wildcat turner pulled by a farm tractor was used. Initially, turning was done every 3 days. Temperature was monitored before each turning. By the end of the first week, as shown in Table 4, temperatures reached 150 to 154 degrees Fahrenheit. For two days following each addition of water, increases in temperature were observed.

After one month, the WCC was observed to form small ball-like masses the size of nickels. This appeared to be due to the mechanical action of turning. These structures did not seem to retard decomposition as at first feared. By the end of two months, these structures had disappeared, and it was difficult to distinguish any WCC in the compost mixture. By the end of the third month, a stable, dark brown compost was obtained.

CONTAMINENTS IN WCC

The Clean Washington Center (CWC) study done by E & A Environmental Consultants, Inc. in 1993 identified potential contaminants in WCC. Potential contaminants include trace metals (printing inks), boron (adhesives), and volatile and polycyclic aromatic hydrocarbons (petroleum waxes).

Compost produced in our pilot project exhibited very low metals concentrations. In fact, metals concentrations from compost produced in our pilot were many orders of magnitude lower than those produced in the CWC study. For example, the CWC identified lead at 11 mg/kg in finished compost containing WCC while Hall County's results were <0.10mg/kg, as shown in Table 5. This is undoubtedly due to the fact that the WCC used in the CWC study was from grocery stores. WCC from grocery trade tend to be more heavily imprinted with labels, logos, etc. WCC from poultry industry sources are largely used internally and need not be imprinted. The boxes are basically ink free.

Boron found in compost made from WCC originates from borax, which is added to starch glues for improving adhesion in the construction of corrugated cardboard boxes (WCC and OCC). Although boron is a plant micro-nutrient, exceedingly high levels can be phytotoxic at 100 ppm and can terminate the composting process completely at the range of 1000-2000 ppm (Davie). Boron concentration found in our composite sample from the field trial at 20 ppm was remarkably similar to concentrations found in the CWC study where 10% by weight WCC was composted (ranged from 18 to 21ppm).

Table 5. Windrow composite sample[1] test results

Parameter	Results As Received	Dry Basis	USEPA 503[2]
Moisture	35.28 %		
pH	7.64		
Phosphorus	0.59 %	0.91 %	
Nitrogen	0.68 %	1.05 %	
Potassium	0.65 %		
Carbon	10.50 %	16.23 %	
C:N Ratio	15.4:1		
Copper	0.71 mg/kg		1500 mg/kg
Zinc	0.61 mg/kg		2800 mg/kg
Lead	<0.10 mg/kg		300 mg/kg
Chromium (total)	0.005 mg/kg		N/A
Cadmium	0.01 mg/kg		39 mg/kg
Nickel	0.12 mg/kg		420 mg/kg
Arsenic	0.04 mg/kg		41 mg/kg
Barium	<0.15 mg/kg		N/A
Boron (total)	20 mg/kg		N/A

[1] A composite compost sample (broiler litter/hen manure) was taken on 12/19/96.
[2] 40CFR503 federal regulations for utilization of biosolids (sewage sludge) compost

The Clean Washington Center study also examined the material safety data sheets (MSDS) for several Citgo wax coatings used in WCC. These MSDS's indicate that the wax coatings are not toxic, carcinogenic, animal carcinogenic, mutagenic, or teratogenic. The WCC boxes are also approved by FDA for use in food packaging containers.

PROJECT CONCLUSIONS

Waxed corrugated cardboard is a very good source of carbon and may be composted with broiler litter or hen manure successfully. Good composting practices should apply with this material as well as any other of this type. From our tests, we do not see any problems that would limit the use of the compost. The finished material may be marketed in the horticultural as well as the agricultural area and used at normal application rates without problem.

The project has the potential to eliminate a substantial amount of the solid waste stream. There is currently no practical disposal alternative for waxed corrugated cardboard. The project supports north Georgia's poultry industry, which is the region's largest employer and economic base. The project stands to offer a viable disposal alternative cheaper than the cost of landfill disposal, while producing a valuable, value-added product. While the major benefit may be derived by the poultry industry, the economic importance of this business sector is of such importance to the region that benefits will cross boundaries. Landfill life will be extended to the benefit of everyone. The project will result in the reuse of a resource as well as offer improvement to our soils, which lack humus.

We were fortunate to have a facility made available to us by Lee Arrendale Correctional Institute and the help of the Chestatee-Chattahoochee RC&D Council, Inc. and feel that both should be recognized for their efforts in this project.

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