OEMC Mortality Composting Project

Project Overview

The objective of the project was to evaluate the viability of utilizing the EcoPod system (model CT10) for hog mortality composting on both large and small-scale agricultural entities.

Evaluation should include impact on energy conservation, pollution and or waste diversion, practicality of operation, mobility of the system, ability to use equipment normally found on small and large operations alike, cost of operation, environmental impact, regulatory compliance, and quality of compost material produced.

Project Operations Summary

On April 21, 2000 EcoPod equipment was mobilized to National Hog Farms compost site and set up. The site was prepared by leveling and clearing an area of approximately 2 acres which would be capable of handling the project.

On April 24th, a mixing bin was constructed using 1 Ton square bales of straw. Various bulking agents were brought to the site. Bulking agents included horse manure and bedding (wood shavings, straw, etc.), coarse ground wood pallets, ground yard waste, shredded paper, and fine ground pallet wood and sawdust.

On April 27th, filling of the EcoPod was begun. Various mixtures of small and large pigs and birth tissues were utilized. Moralities were weighed along with bulking agents to determine the mixture percentages. Large pigs were splayed.

Air was supplied to the bag utilizing the blower/generator setup. The EcoPod was completed and sealed on May 4th. A total of 130 tons of mortality/bulking agent mixture was placed in the EcoPod prior to sealing, of which 12.7% was mortalities and birth-related tissues. The bag measured approximately 161 feet in length.

Surface vents were installed on the EcoPod and air supply was initiated. Blowers were set at 2 minutes on and 5 minutes off. From this point until the EcoPod was harvested, operations consisted of obtaining temperature data, some sampling, and monitoring for odors or other environmental conditions. Vents and air supply were adjusted to assist in obtaining maximum temperatures in the bag. Temperature measurements were taken at 10”, 20”, 30”, and 40” depths at each vent location.

Temperatures in the EcoPod reached 70 degrees Celsius plus around the first of May and then began declining. By June 29th, POD 1 had declined to around 35-40 degrees, POD 2 to around 45 degrees, POD 3 to 45-50 degrees, POD 4 to around 60-65 degrees, and POD 5 to around 50-55 degrees.

Supply air was continued and the EcoPod monitored throughout July. No noticeable problems were observed, and temperatures continued to decline slowly.

On July 31, 2000 we opened three sections in the bag, approximately 4' wide by 3' high and checked the contents for moisture, bulk density, and composting uniformity. It was observed that the outside 1-2' was wet and soggy, smelled moldy, had an average % moisture of >60% and had a bulk density of around 30 pounds per c.f. (810 pounds per cubic yard). The material appeared somewhat composted.

The inner material was very dry, hard packed, with some signs of bacteria, and smelled like wood. Average moisture was < 15% with bulk density in the < 15 pounds per foot or 400 pounds per cubic yard. The material was so tight that it could only be penetrated with a shovel about 2'. Based on these observations, it was decided that, since it would be very difficult to get additional moisture back into the middle of the EcoPod material, that composting was probably at an equilibrium state.

On August 8th, the EcoPod was harvested by removing the outer plastic material and disposing of it in a landfill. The following observations were made:

1. The outside of 2' material, for the entire length of the bag, was very wet and the inside material was very packed and dry. It appears the air system of the bag pulled moisture from inside the material and refluxed it in the outside 2' making the surface very wet and the inside dry. Condensed water puddles were found along the bottom of the bag in several places.

2. Although the bulking agents were not composted, as a whole, the dead pigs were. Only a few animals' tissues were not completely composted. Most of the boneless body material had been broken down and had composted with some of the bulking agent to make blackish, slightly greasy, musty-smelling compost. The animals that had not been completely composted were in the wettest part of the row and had definitely gone anaerobic. The animal tissue remained pink and the odor was rancid. The body fats were very prominent making the area where the animal was greasy and the material glistened in the sunlight.

3. There were few bones from small animals, but many skulls and leg parts were found for the sows which were >250 lb in most cases. After the material was piled

in a windrow and turned, the bones began to shatter and break up. The heat generated in the bag during the composting process yellowed most bones. Only the bones from the few rancid pigs had meat attached or were not yellowed by heat. Again, this indicates that these few pigs were in an anaerobic process probably due to too much moisture in the surrounding area with little or no contact with air.

4. Samples were taken from several areas of the row, before and after the bag was harvested. The compost data sheets show the differences between the pre-harvest compost (labeled on the data sheets as "DateOngoingTests") and the post-harvest compost (labeled "DatePiled"). In all but one mix (mix 4), the pre-harvest fecal coliform was less than the EPA 503b Biosolids 1,000 MPN/g limit before the material was removed, windrowed, and turned. The turned or well-mixed compost samples all had greater than the upper observable limit of 4,800 MPN/g. This post-harvest emergence of fecal coliform indicates that the composting process was not complete in the EcoPod.

5. The ammonia/nitrate ratio also shows that the composting process was incomplete. Ammonia is converted to nitrate during composting and should be in trace amounts when the compost is finished. Nitrate should be the most abundant form of the two and the ammonia/nitrate number should be less than 1.

6. Temperatures increased by >30 degrees Celsius after the windrow was formed with the bag material and turned with the compost turner. The rapid increase in temperature after turning indicates the material was oxygen-starved and that there remained much material to be composted. Water and manure were subsequently added as most of the bulking agent was not composted and thus could not be screened to deliver finished compost.

7. The EcoPod material was moved to a windrow configuration. Additional moisture was added and the composting process initiated again. Temperatures were again monitored daily.

When declining temperatures indicated that the composting process was completing itself, the material was allowed to cure in the windrow for a few days and then screened over 1/2" mesh screen on November 16th.

Impact on Energy Conservation

The impact on energy conservation by utilizing the EcoPod is difficult to determine. It is my opinion that there is not significant savings nor additional impact to energy conservation and or use when using this system. Conventional disposal of the materials includes rendering and landfill disposal, both of which involve transportation and fossil fuel usage. The EcoPod system itself involves little use of electrical power during the process. However, fossil fuels are used by the equipment needed to load the bagging machine and by the machine itself. Non-reusable items such as pipe and the pod itself must be disposed of in landfills, or could be recycled by PET material recyclers if they could be cleaned first. Additionally, fossil fuels may need to be used for additional windrow activity and screening activity if desired.

Pollution and or Waste Diversion

Composting is an excellent waste diversion vehicle. In fact it is the ultimate recycling activity since it returns its materials back to mineral form (earth to earth per say). There is some concern for nitrate pollution from composting operations. On properly designed and operated facilities, this is usually a non-issue. The EcoPod system in particular poses little to no risk of pollution since it is, in essence, an in-vessel composting technology.

Practicality of Operation

Practically speaking the EcoPod is not a good fit for regular small scale mortality composting unless there are special circumstances. It is my understanding that it can and is being used successfully for non-mortality composting (yard waste as an example).

Mobility of the System

The system is designed to be mobile and indeed is. The unit we utilized (CT10) can be moved legally by small truck. Any of the systems could be shared and used by multiple farms. It is also mobile on the site and can be moved around a production site easily.

Ability to Use Equipment Normally Found on Both Small and Large Operations

Equipment normally found on both large and small operations could be utilized with this system. The hopper on the bagging unit can be fed with loaders ranging from smaller skid steer type loaders to larger wheel loaders. The entire EcoPod process can be completed using a loader without special equipment unless the windrowing method is also used. While a loader can be used to aerate, mix, and move the windrows, aeration is best accomplished with equipment designed for that purpose. There are numerous models of aeration equipment available.

Cost of Operation

Costs associated with conducting the pilot program were as follows:

Equipment and Related Services:	$26,851.76
Supplies:	$ 4,161.07
Personnel:	$13,010.71
Mobilization & Travel:	$ 2,727.23
Administration:	$17,560.37
Total Project Cost	$64,311.14

Estimated normal cost of operation for the EcoPod system would be as follows:

- Supply Costs (pod, seal strips, piping, fittings, vents): $6.00 - $6.50 per ton of initial material going into the pod.
- Capitalized Costs (machine and blowers), based on 10,000 tons per year minimum of material going into the pod: $1.00 to $1.50 per ton of initial material going into the pod.
- Energy Cost: < $.20 per day per blower operated if utilizing standard permanent electrical source.
- Total estimated cost of operation for EcoPod system alone: $7.20 - $8.20 per ton of material going into the POD.

Additional costs to consider would include costs for a loader and operator, which may or may not be allocated to the operation based on individual operation decision.

Environmental Impact

Environmental impact of the EcoPod system is minimal. An advantage of the system is that the bag eliminates contact of the composting material with the soil, controls leachate and or contact moisture runoff, and reduces or eliminates wind blown debris problems. It also seems to significantly control odor problems. There were some problems with vectors (coyotes) digging into the bag. This was probably due to mortality odors coming from those areas in the Pod that had anaerobic conditions. Fly and insect numbers were reasonable.

Regulatory Compliance

The EcoPod system may or may not be subject to regulations contained in Colorado Regulations Pertaining to Solid Waste Disposal Sites and Facilities (6 CCR 1007-2, Section 14). These regulations allow the Department to make case by case determination as to applicability.

However, it is my interpretation that if the EcoPod system is utilized for agricultural activities by the generator only, who only imports compatible material necessary for the composting process of the generator’s waste, is utilized at the site of generation or on contiguous property owned or leased by the generator, it would then be exempt from the regulations (Colorado Regulations Pertaining to Solid Waste Disposal Sites and Facilities (6 CCR 1007-2 Section 14.1.2). Applicability to hog farm operations would be subject to interpretation based on Amendment 14, which regulates hog farms separately from other confinement feeding operations.

If the EcoPod system is utilized by a facility that falls under a regulatory classification as listed in Section 14 and summarized on the attached chart, then the EcoPod system could be beneficial by eliminating the requirements for hard surface, leachate control, and windblown debris control.

It is also possible that since it is an in-vessel system, that it would be acceptable for use under Amendment 14 restrictions.

Final Compost Analysis

All tables and figures referenced in the following sections are found in Appendix A. A separate CD contains the complete Power Point Presentation by A1 and pHE at the AFO/CFO meeting in Denver, Colorado on 12/6/00 and all photos taken during the study.

Temperature:

- The EcoPod was monitored for temperature from start to finish on both sides of the row at 10, 20, 30, and 40 inches using a 40-inch probe fitted with 4 thermisters. The probe was connected to a four-channel recorder and temperatures were logged onto a temperature data sheet each day.
- Before the bag was harvested, the probe was inserted into a bag valve alternating from the west to the east side of the bag each day. Each valve or set of valves corresponded with a specific mix in the bag and were identified thusly.
- The bag was harvested using a bucket loader. During the process of making a new row from the de-bagged material the mixes were marked with flags and temperatures taken by mix alternating from side to side each day (see Figure-1: A1 Organics EcoPod Mix, Valve, and Windrow Diagrams).
- The temperature charts show that the temperature started at approximately 75 to 80^{0}C and declined without the characteristic thermophillic bacteria temperature plateau reminiscent of most composting processes. Figures 2 through 6: EcoPod Temperatures @ 10”, 20”, 30”, and 40” show the different mixes’ temperature profiles and Figure-7: NHF Bin #2 Temperatures @ 10”, 20”, 30”, and 40”shows a temperature profile from one of

NHF's compost bins. Note the missing plateau from left to right on the EcoPod's charts when compared to the NHF chart.

- The charts also show the sharp increase in temperatures after the bag was harvested. Temperature increases of this magnitude are associated with compost that has not been finished properly (see the following Compost Quality analysis discussion).
- Although the bag temperatures started above 70^0C, the thermophilic stage did not last long enough to kill off the fecal coliform bacteria (see Table-2: EcoPod Compost Quality)

Compost Quality

Table-1: Some General Characteristics for High Quality Finished Compost shows important compost quality characteristics that were used to evaluate the EcoPod compost after de-bagging and after windrowing.

Samples were taken immediately after de-bagging from the unmixed material (AB) and then again immediately after the new windrow was formed and turned (AM). The data from these samples were then compared to Table-1 along with final samples (F) taken on 10/18/00. Table–2 shows the comparison data from samples AB, AM (selected), and F for each mix (values in red indicate those compost quality characteristics that fell out of acceptable ranges as per Table-1).

Figure- 8: EcoPod Compost Particle Size > 1/2 inch (%) shows that not all of the mixes' particle sizes were reduced to a quality size during bag composting (particles >1/2 inch should not exceed 5-10% of the total). Only mixes 2 and 9 had, out of the bag, % reductions under 20% and mix 3 (greenwaste) had the highest level of >1/2 inch particles at over 60%. The AM samples for mixes 3, 4-7, and 8 were all above the 10 % limit. However, an acceptable particle size for F samples was reached in mixes 4-7, 8, 9, and a sample containing all of the mixes after several weeks of open windrow composting with turning and additions of water and some solids. Mix 3 was reduced from > 60% over the 10% limit to 11% which would be acceptable. Only mix 2 showed little reduction but was under 20% from start to finish.

Figure-9: EcoPod Nitrogen Series is a chart depicting the four different nitrogen analyses (total nitrogen, organic nitrogen, ammonia, and nitrate) and how they differed over time from the de-bagging to final compost. Total Nitrogen is a measure of the ammonia, nitrate and organic nitrogen. Organic nitrogen is the slow release nitrogen that makes compost a good soil amendment as this nitrogen is released as the plant needs it thus reducing leaching. Organic nitrogen is the total nitrogen minus the nitrate and ammonia. Ammonia is used by bacteria to produce proteins and converts ammonia to nitrate. If there are high concentrations of ammonia at the end of composting cycle then composting did not proceed as expected. High concentrations of nitrate relative to ammonia indicate composting occurred, however, nitrate can leach to groundwater and burn plants if at too high a concentration. Therefore, high quality compost is characterized by an ammonia / nitrate ratio of <1 and an organic nitrogen concentration close or equal to the total nitrogen concentration.

Table-1 shows that when the ammonia / nitrate ratio is < 1 the compost is of acceptable quality. Table–2 shows that mix 2 never exceeded the ammonia / nitrate ratio even after bagging. Mix 3, the greenwaste mix, was 4 after bagging and the final was 0.12, clearly under the <1 limit. Mix 4-7 ranged from 1,189 to 11 for the AB and AM samples and ended with an F number of 4, somewhat above the <1 limit. Mixes 8 AM and 9 AB both had high numbers (>1,000) but the F samples were below the acceptable limit. The sample of the combined mixes had a 0.89 which was below the acceptable limit indicating that when all of the mixes were combined, an acceptable ammonia / nitrate ratio could be achieved. The low out-of-bag ammonia / nitrate ratio numbers for mix 2 and 3 are misleading. Figure-9 shows that ammonia was present after de-bagging in both mixes but that the nitrate concentration was higher due to more complete composting occurring in the outside wet layer. Once the material was mixed the AM samples show the ammonia level is increased and the nitrate reduced from mixing of the wet outside layer and the inside dry layer.

Table–1 and Figure-10: EcoPod Compost Data show the C:N ratio and the AgIndex. Table-1 states that an AgIndex >10 and a C:N ration of <10 are good finished compost characteristics. The C:N ratio (carbon / nitrogen) is another measurement of nitrogen. In this case the higher the nitrogen the better when compared to carbon. If a final compost has a high C:N ratio, then when mixed with soil, the bacteria present in the soil will use any available nitrogen (needed by the plants) to continue the composting process while converting the excess carbon to carbon dioxide. This in-soil composting not only uses valuable nitrogen needed by the plant but also robs the soil of oxygen, reducing oxygen availability to the plant. The AgIndex is an indirect measure of salt concentration in the final compost. The AgIndex is the nutrients (Nitrogen + Phosphate + Potash) / Sodium Chloride. A number >10 indicates the sodium chloride is low compared to the nutrients and salt damage would be unlikely.

The F samples had C:N ratios of 14 or above for all of the mixes except mix 3 F (C:N of 13). The sample with all of the mixes was at 18 and this clearly indicates that even after windrowing and turning an acceptable C:N ratio was not obtained. The AgIndex was, for the most part, acceptable with the F sample for all the mixes being >10. Mix 2, Mix 8, and Mix 9 had final compost levels under 10 (6.5, 6.7, and 8 respectively). However, these levels would be okay for most agricultural usage as would the 18 C:N ratio.

Table-1 shows germination and growth criteria. This test involves mixing the compost sample with vermiculite in a 1:1 ratio and planting a known number of cucumber seeds into the mixture. The number of seeds germinated are compared to a positive control such as potting soil and negative control vermiculite. Vermiculite is used in the mix and as a negative control because it contains no nutrients and contributes nothing to plant growth. The relative seed vigor part of the test shows whether the seeds grow well after germination or are hindered by some component in the compost. Good compost will have a germination value as good as or better than the potting soil and better than the vermiculite and a relative seed vigor of at least 95%. Figure–11: EcoPod Germination And Growth Data shows that the final compost (F) had germination values of 90% or above for all but mix 8 and that the compost mixes were higher than vermiculite with the exception of mix 8. However, some of the potting soil values were exceeded by AB and AM samples from mixes 2, 3, 5, 8, and 9. Compost samples for mixes 8, 9, and the combined sample (all of the final mixes) were the only F samples to meet or exceed the potting soil values. The relative seed vigor was high for all of the samples but mix 8. The vigor values indicate that plants, once germinated, should grow well in the compost. It would be more helpful to have a series of dilutions with the compost and vermiculite to aid in determining the best mix of compost to soil ratio.

The two remaining EcoPod analyses items from Table–2 are fecal coliform and odor. Table-1 shows that fecal coliform should be <1,000 MPN/g to meet the EPA Class A 503b standards for a treated municipal sludge. Fecal coliform is a group of bacteria found in the gut of most mammals and is present in manure. Fecal coliform will make humans sick if exposed to large quantities. Fecal coliform bacteria are also used as an indicator bacteria for the presence salmonella and other pathogens. NHF has always considered good compost to have fecal coliform bacteria <100 MPN/g. Odor similar to freshly turned soil is the odor that most composters strive for and is an indication that composting went well and the smelly stuff was converted to the good clean earth odor. Bad odors are an indication of incomplete compost (i.e. starting materials such as manure not completely broken down).

Compost may not finish properly due to the following:

- It was starved for air
- Starting materials were not well mixed
- The starting materials may have been too wet or too dry

In the case of the EcoPod, all were true. After a period of time the moisture was lost from the center of the bag's material to the outside 2 feet. This moisture movement left the center of the row too dry (10% moisture) and formed a 2-foot wet outside ring (>35% moisture) around the compost for the entire length of the bag. Pools of blackish liquid were found at the bottom of the bag. It appears the airflow provided by the fans was over the material and not through the material.

When the fans were activated the bag would expand and the moisture would volatilize and condense on the bag's surface. The bag would then collapse upon fan deactivation leaving moisture on the compost' surface. The wet areas then would go anaerobic and if a mortality was present its tissue would not be decomposed but would rot and stink. This condition was found in a few spots but was most apparent in mix 3, which was greenwaste and water, no high nitrogen swine separated solids were used in this mix. Figure-12: EcoPod Physical Data (After De-Bagging) shows that H2O% (% moisture in material) for all of the AB mix samples were higher than the AM samples. The four mixes sampled for AM H2O% have an AM H2O% difference of from approximately 10% (mix 3) to as high as 25% difference for mix (4-7) from AB to AM. This moisture difference adds credence to the above discussion.

Also, the material was mixed using a bucket loader prior to filling the bag. This type of mixing can be used if the row is periodically turned or aerated. However, the bag does not allow continued turning so the mix remains as good as or as bad as when the bag is filled.

In most mixes the fecal coliform was very high after de-bagging (AB samples) and after mixing (AM samples) but all final samples were reduced to below the EPA limit of <1,000 MPN/g and only mix 3 (greenwaste) did not have fecal coliform below the more stringent NHF standard of 100 MPN/g. The odor was also reduced from a strong presence to slight in every mix and had obtained the earthy odor after screening on 11/16/00.

Compost Quality Summary

Table-3: EcoPod after Screening shows the beginning starting material tonnage and the final screened compost and non-composted material. However, the screened compost is not a true reflection on how well the EcoPod composted the dead pigs and bulking agents but rather the entire process from the bag through windrowing. The after bag samples (AB) and post bag observations (as summarized in Tables 4 and 5: EcoPod Compost Study Conclusions) provide the most useful insight into the out-of-bag compost quality.

The compost samples taken after bagging would not be accepted as a **Class-A biosolids** as per the EPA 503b fecal coliform criteria alone. Temperatures, although high at the beginning, did not reach a proper thermophilic plateau until after hydration, aeration, and conventional turning. Mix 3, as mentioned above, used only greenwaste for a nitrogen source and had the most odors and undigested animal tissue and had the most rejects after screening. Figure–9 shows its total nitrogen concentration was close to its organic nitrogen concentration, but that was because all of the ammonia was used by the bacteria before composting was complete. Greenwaste could be used if an additional source of nitrogen was added to the contents. The final compost, after aerating with a conventional compost turner, would be acceptable for most agricultural uses. But the bag used as a sole composting method would be unacceptable for producing a “better than” agricultural final compost if animal manures and mortalities were in the mix.

References

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3. The Midwest Plan Services, Livestock Waste Facilities Handbook, 1993.
4. Northeast Regional Agricultural Engineering Service, On-Farm Composting, 1992.
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Appendix-A

EcoPod Compost Report Figures 1-12 and Tables 1- 2

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