CLARION COMPOSTING PROJECT

Donald Wetterauer
Postdoctoral Research Associate
Department of Agronomy
Iowa State University

Introduction

In Iowa and other parts of the U.S. the number of animals raised in livestock confinement facilities continues to increase. Residents in many rural areas are concerned about the quantities of manure that will be generated at these facilities and how this will affect their quality of life. Land application of the manure is currently the primary method of using the manure. However, environmental concerns may impose regulations that limit how the manure is applied. Alternative methods of manure utilization are needed.

Iowa communities are faced with another problem. In an effort to reduce the materials entering landfills yard waste will not be accepted for disposal. This means that communities must find alternative disposal methods. Some cities provide an area where yard waste may be collected and there may be some sort of charge for this service. The city then can attempt to compost the material for re-use in the community or, sometimes simply look for areas for land application. Many times community-wide efforts to deal with yard waste do not exist.

Yard waste alone may not be a particularly good compost material. To make a good compost using leaves and wood chips for example, a source of nitrogen is needed. Grass clippings can provide nitrogen but they tend to pack together creating anaerobic conditions in the pile making composting difficult. Poultry manure is an excellent nitrogen source and provides bulk to help keep the compost pile aerated. When poultry manure and yard waste are combined the mixture develops into compost that is a source of plant nutrients and organic matter that may improve soil structure, reduce fertilizer requirements, and in some applications, reduce the potential for soil erosion.

The methods of composting and benefits of using compost are well known. The objective of this project was not to research composting but to develop a cooperative effort between agriculture and rural communities to turn two different disposal problems into a valuable resource. The project is also a demonstration of how a simple composting operation might work for a rural community. Using animal manure for compost produces a stable product that can be land applied without concerns for environmental contamination. In addition, residents of rural communities will have a convenient way to dispose of most yard wastes. The return benefit is a compost that will be in demand by gardeners and landscapers. In fact, the potential demand for compost is estimated to be an order of magnitude greater than the potential supply, according to a study by the Battelle Institute (Slivka et al., 1992). In other areas of the country composting has provided additional income for farmers and helped ease landfill problems. Tipping fees for accepting compostable yard waste can generate $5 to $10 per cubic yard of waste. The finished compost can also be sold. Finished compost prices vary from $5 per cubic yard in bulk to $50 per cubic yard for refined horticultural grade material. In general, one ton of compost yields about two cubic yards.

Composting is a good manure management practice because the process stabilizes nutrients and reduces the original volume of the manure by at least 50%. The nutrients in the manure are converted to organic forms that are slowly released as the compost decomposes. The reduction in volume, mainly through the loss of water, makes the compost easier to handle than the fresh materials.

Composting Basics

Composting is the biological decomposition of organic materials by microorganisms. Four important characteristics of the compost pile determine the rate of decomposition and the quality of the finished compost: oxygen, moisture, temperature, and the carbon:nitrogen (C:N) ratio of the raw materials. It is important to remember that the decomposition process is aerobic. Many of the complaints directed at composting operations are because of odor. Odor can become a problem if the compost pile becomes anaerobic and fermentation starts. Maintaining proper air flow through the pile is essential to the composting process. Oxygen levels of 5 to 15 % are usually recommended (Iowa Department of Natural Resources, 1991). Moisture is another factor necessary to support biological activity. The moisture content of the materials in the compost pile should be in the 40 to 60% range. Moisture and oxygen content are related. If the pile is too wet then the oxygen content will decrease and anaerobic conditions may exist. At lower moisture contents biological activity slows and eventually ceases entirely. As the decomposition process proceeds the internal temperature of the compost pile will increase due to the biological activity. Different microorganisms are active at different temperature levels. Below 105 ^{0}F mesophilic organisms are active. Above 105 ^{0}F thermophilic organisms thrive. It is generally recommended that thermophilic temperatures be maintained during the active composting process. At thermophilic temperatures the decomposition of organic material is faster than at lower temperatures. In addition, most pathogens are destroyed at temperatures above 130^0 F and most weed seeds are destroyed with temperatures above 145^0 F. Finally, the C:N ratio of the ingredients determines the rate of decomposition and the final nutrient content of the compost. Mixing materials that are too high in nitrogen will cause odor problems. If the carbon content is too high then the decomposition will be slow and incomplete. An ideal C:N ratio is 25:1 to 30:1 (Dickson et al., 1991; On-farm composting handbook, 1992).

There are a variety of methods for composting depending on the space and equipment available. Generally, the size of the compost pile is designed to fit the particular characteristics of each operation with the basic concepts of composting in mind. Large piles will hold heat but may lack adequate oxygen penetration. Small piles allow too much heat to escape making it difficult reach thermophilic conditions. Pile aeration and temperature can be controlled by turning the pile. Many composting operations use pile temperature as an inexpensive method of monitoring the composting process. If an immature compost pile is too cool then the oxygen content may be low. Turning the pile will mix in oxygen and pile temperatures should begin to rise. Turning may also be necessary to lower pile temperatures. As the active composting process nears completion pile temperatures will begin to drop to near ambient air temperatures. When turning the pile no longer results in increasing temperatures then the active phase of composting is probably complete. Then the compost is usually moved to another area for a period of curing that may last for a month or more. During the curing period biological decomposition of resistant compounds, such as some organic acids, continues. If the active composting process was not managed properly or the composting period was too short then the curing period will be necessary to avoid plant growth problems associated with using immature compost.

Composting methods vary depending on the method used to incorporate oxygen into the pile. The simplest method is the static composting pile. The mixture of raw materials are placed in a windrow and turned very infrequently during the composting process. Next on the list is the typical windrow type of operation. Raw materials are placed in windrows and the pile is turned frequently using bucket loaders or rotary-type compost turners. A more sophisticated composting operation uses piping and blowers to force air into the pile eliminating the need for turning equipment. In-vessel composting relies on forced air and mechanical turning of the pile during active composting. In-vessel operations allow more control over conditions like moisture and aeration and may be somewhat less labor intensive than other composting methods.

Clarion Composting Project

On May 22, 1995 the first compost pile was established by the city of Clarion, IA. The initial compost windrow was about 12 feet wide, 8 feet high, and 75 feet long. These dimensions were large enough to maintain heat generated by the compost and small enough to allow air infiltration. The size of the windrow was also tailored to accommodate the bucket loader used for turning the pile. Yard waste (leaves and grass clippings) and poultry manure were mixed in a 1:1 ratio. A 1:1 ratio of yard waste to poultry manure was used because the yard waste contained a high percentage of grass clippings which are a good source of nitrogen. Remember, the ideal C:N ratio is 25:1 to 30:1. In order to keep from oversupplying the system with nitrogen a lower amount of yard waste was used. Yard waste with a higher content of leaves and woody material could be mixed with a higher amount of manure, three or four parts manure to one part yard waste The yard waste and poultry manure were hauled to the composting site by Clarion Public Works employees using a city dump truck. A city tractor with a bucket loader was used to mix the raw materials and form the windrow. The same tractor was used to turn the compost as needed, depending on pile temperature. During the active composting phase the pile was turned nearly every week.

The moisture content of the poultry manure was about 43% and provided the right amount of moisture for the compost pile. Based on the characteristics of the pile during active composting the ratio of materials was about right. We were able to keep the pile at the proper temperature and there was very little odor. This indicated that there was not an excessive amount of N in the raw materials, the moisture content of the material was good, and that there was adequate air infiltration preventing anaerobic conditions. After 100 days the temperature of the windrow was near ambient air temperature and the active phase of composting was complete. The first batch of Clarion compost was moved to a curing pile and made available for distribution. The second windrow was established at the site on 1 Sept 1995 using the 1:1 ratio of yard waste to poultry manure. The second pile is expected to have a longer active compost period because of lower ambient air temperatures during the fall and winter and was ready for distribution in April, 1996. A third pile was started in late summer of 1996 using the same 1:1 ratio of yard waste and poultry manure.

The first compost pile finished out at about 130 cubic yards of material. The commercial value of compost varies from about $5 to around $50 per cubic yard depending on the grade of the compost. At minimum value, the first windrow of compost produced in Clarion was worth about $650. Clarion Public Works Director Jim Redemske estimated that the city invested about $650 in the first pile. Assuming the minimum value for the compost, then the city would just break even if the compost had been sold. However, in order to have a compost material that would be suitable for sale to the general public a greater investment in time and equipment would be necessary. Equipment costs on the order of $50,000 would be needed to purchase specialized composting equipment.

Of course there were a few minor problems that occurred. The main difficulty encountered during the first year of the project was mixing the compost using a tractor mounted bucket loader. The poultry manure tended to ball up into clumps that were up to 6 inches in diameter. Every time the pile was turned the clumps tended to break up some but they did not completely disappear. A compost turner would have made the job of turning the pile easier and could have broken the large masses of compost into smaller more manageable material. Another problem was small twigs and branches in the yard waste. Again, a compost turner would have done an excellent job of chopping this material into smaller particles. The city has a separate waste pile for branches and tree limbs and that helped keep more of that kind of material from ending up in the yard waste used for composting. Frequently, other composting projects have had problems when composting yard waste as cans, bottles, and plastic materials may end up with the raw materials. We found these materials in the Clarion yard waste, but people in Clarion are very supportive of the project and this problem was kept to a minimum and easily managed.

We were concerned from the start of the project about potential odor problems. The most frequent cause for closing composting projects in the past has been odor complaints. The city of Clarion has a caretaker living at the airport, about 50 yards down wind from the composting site, and he reported he noticed no objectionable odors during the active composting phase of the project.

Compost analysis

A sample of the poultry manure used for the project was collected on 22 May 1995 as the windrow of yard waste/manure was established. The manure sample was stored in an air-tight plastic container at 35^0F over night for laboratory analysis. A composite sample of the finished compost was collected on 28 Aug 1995. After air-drying the sample was analyzed for total-nitrogen (total-N), total-phosphorus (total-P), total-potassium (total-K), nitrate-nitrogen (NO_3-N), ammonium nitrogen (NH_4-N), a measure of soluble salts or electrical conductivity (EC), and pH. The laboratory results are shown in Table 1.

Assuming that the yard waste used in the compost originally had a concentration of about 3% total-N (an average value for a mix of grass clippings and leaves) then about 50-60% of the total-N from the original poultry manure/yard waste mix was lost. A large part of the N lost was probably from ammonia volatilization. Early in the active composting phase, when the pile was turned an ammonia odor was usually noted. An increase in concentration of NO_3-N of the finished compost indicates that some of the NH_4-N was probably converted during the active compost period.

A number of characteristics are used to determine the quality and grade of compost including color, odor, pH, particle size, and soluble salt content. We only evaluated the pH and soluble salt content of the Clarion compost. The maximum salt concentration (EC) of soil amendment grade compost should be less than 20 mmohs/cm. For horticultural use as a top dressing for lawns or potting mixtures the soluble salt concentration should be less than 6 mmhos/cm. The relatively high concentration of soluble salts in the Clarion compost (EC, 13 mmohs/cm) limits use of the compost to land application as a soil amendment for gardens and field crops. Recommended compost application levels should not exceed 50 dry tons per acre or about 4 cubic yards per 1000 square feet (On-farm composting handbook, 1992).

Table 1. Chemical analysis of the poultry manure mixed with the yard waste to form the initial windrow and Clarion compost finished product.

	Poultry Manure	Clarion Compost
Total-N (%)	3.8	1.4
NH_4-N (ppm)	8898	145
NO_3-N (ppm)	17	395
Total-P (%)	3.2	2.2
Total-K (%)	4.1	2.5
pH	8.5	8.4
EC (mmhos/cm)	10.4	13

Water samples
Iowa Department of Natural Resources (DNR) regulations specify the requirements for operating solid waste management facilities, including commercial composting operations, to prevent environmental problems. A particular concern when using animal manure for composting is the leachate and the possibility of nitrate-nitrogen from the pile contaminating surface and groundwater.

Before the first windrow was established, 8 suction cup lysimeters were installed at the composting site. The purpose of the lysimeters is to collect samples of soil water for NO_3-N analysis. The site was arranged for two compost piles to be active at the same time and two lysimeters were placed at the ends of each pile. There was a space of about 12 feet between piles to provide access for turning operations.

The first water samples were collected from the site on 5 June 1995, about 2 weeks after the first compost pile was established. At that time, NO_3-N concentration of the soil water was less than 3 ppm. Forty-two days after the first compost windrow was established NO_3-N concentration of the soil water samples reached the highest recorded level of 11.7 ppm. Water samples were collected weekly until the ground froze in November and NO_3-N concentrations were much lower, less than 6 ppm.

Pile temperature
Temperature of the pile was monitored daily using a thermometer with a three foot probe. About 4 days after the first windrow was established pile temperature had risen above 120 ^{0}F. Maximum recorded temperature in the pile was 145 ^{0}F. Temperature of the compost was used as a guide to determine when it was necessary to turn the pile. The goal was to keep pile temperature around 140 ^{0}F to provide suitable environment for microorganisms and to destroy weed seeds and pathogens. To control the temperature of the compost and maintain adequate aeration the pile needed to be turned about once per week.

Conclusion

The Clarion composting project was a success. The community support was overwhelming. Community residents supplied the city with yard waste and poultry manure was supplied by a local egg producer. Over 150 residents of the area attended presentations at the site. About 200 cubic yards of compost were distributed to gardeners and farmers so far and there is considerable interest in continuing the project after the two year demonstration period. Several other communities in the area are interested in the possibility of starting a combined composting effort to share equipment costs.

References

Dickson, N., T. Richard, and R. Kozlowski. 1991. Composting to reduce the waste stream: A guide to small scale food and yard waste composting. Northeast Regional Agricultural Engineering Service, 152 Riley-Robb Hall, Ithaca, NY 14853-5701. Pub. no. NRAES-43.

Iowa Department of Natural Resources. 1991. Local government composting guide. Iowa Department of Natural Resources, Waste Management Division, Wallace State Office Bldg., Des Moines, IA 50319-0034.

On-farm composting handbook. 1992. Robert Rynk (ed.), North Regional Agricultural Engineering Service, 152 Riley-Robb Hall, Ithaca, NY 14853-5701. Pub. no. NRAES-54.

Slivka, D.C., T.A. McClure, A.R. Buhr, and R. Albrecht. 1992. Potential U.S. applications for compost. Battelle Institute, Columbus, OH 43201.