Mortality Compost Nutrients and Use On Farm, Ways to Enhance Nutrient Content

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Overview

Nutrients in mortality or animal tissue compost have beneficial worth for plant growth. The extent to which plant growth will be enhanced will be determined by the amounts and availabilities of nutrients in the finished animal tissue compost. Nutrients in finished animal tissue compost reflect the amounts of nutrients present originally at the start of the compost process, the nutrient losses or gains occurring during the composting process, and the mineralization (and other chemical processes) in the soil by which nutrients become increasingly available to plants over time. Relative to management of the animal tissue compost process, potential nutrient losses occur primarily from runoff, leaching, and aerosolization. This paper discusses the value of animal tissue compost and the potential ways to enhance that value through process management.

Introduction

Composting is the biological decomposition of organic material under controlled conditions to a state where storage, handling, and land application can be achieved in a safe, aesthetically acceptable, and environmentally-sound manner. Composting has proven to be an effective process to manage dead animals (Murphy and Handwerker, 1988; Flegal et al., 1993; Fulhage, 1994; Garcia-Sirera, 1995; Rozeboom et al., 1997; Glanville, 1999; Keener, et al., 2000; Bonhotal, 2002; Stanford et al., 2007; Hutchinson and Seekins, 2008).

"Dead animals" are described in most state regulations as the whole bodies and any part of the bodies or any material produced from the bodies of animals that have been slaughtered or have died from any other cause and are not intended for human food. In scientific literature concerning dead animal composting, "animal tissue" may be used to more accurately describe the aggregate of whole carcasses, animal parts and processing co-products. The term "mortality" may also be used. It is most commonly used to describe dead animals in the on-farm composting literature, but on occasion may be used to also include parts of animals. In some states, these descriptive terms may also refer to restaurant grease of animal origin. In the remainder of this paper, the term "animal tissue" will be used.

Feedstocks (a.k.a. bulking agents, amendments, carbon sources) are organic materials placed around whole bodies or mixed with body parts to provide nutrients, desirable density, and aeration. Carbon-rich materials such as chopped bean stover, chopped corn stover, chopped straw, dried grass, grain hulls, chopped dried hay, and sawdust or shavings may be used as amendments. Animal manure solids, partially-decomposed vegetative residues, green grass clippings, fresh hay, green leaves, and litter cake may also be used. Effective decomposition can result from many feedstocks; including others not mentioned here.

The nutrient content of finished animal tissue compost will reflect the nutrients originally found in the animal tissue, and also the nutrients originally present in the feedstocks which were used to enhance decomposition. When the original nutrient content of the compost (including nutrients from the animal tissue) is great, then the resulting final product is more likely to have greater nutrient concentrations as well.

With good management, composting can successfully decompose soft tissues in less than three months. The decomposition of bones may take up to two years depending on the maturity of the original animal. Animal tissues are significant nutrient resources that can be recycled effectively through composting. The objective of this paper is to discuss the nutrient or fertilizer value of animal tissue compost and how it may be influenced by management of the compost process.

Nutrient Content of Finished Animal Tissue Compost

There can be considerable variability in the nutrient content of animal tissue composts. The laboratory analyses of six different finished animal composts are shown in Table 1. These composts were produced in studies completed by our research group at Michigan State University. In Michigan, finished compost must not have visible pieces of soft tissue when applied to fields. Large bones may still be intact and must not be spread on cropland until easily crushed by the spreading process. Finished compost need not be fully cured.

Across these finished animal tissue compost samples, there was notable variation in pH, nitrogen, phosphorus, potassium, calcium, and iron content. The same feedstock mixture was used to produce the two composts represented in the right-most columns. The compost with the "i" designate was managed using an in-vessel system and the compost with the "s" designate was managed using a static pile approach. The metal rotating drum appears to be a source of iron in the finished compost. Feedstock mixtures differed among the other four composts. For the two samples in which soluble salts were assessed, they differed by more than one-fold.

Table 1. Analysis of selected finished animal tissue composts produced at Michigan State University in the past decade.

		Sample ID					
Parameter	Unit	103113	100409	050605	051107	111709i	111709s
Moisture	%	10.0	42.2	50.9	30.4	48.2	41.8
Organic Matter	%	63.4	83.2	70.4	66.2	45.7	51.8
Soluble Salts	dS/m	11.27	27.44	.	.	.	.
Ash	%		.	.	3.42	6.70	6.46
pH	-	5.8	6.4	.	8.6	9.0	8.0
Carbon	%	36.8	38.9	40.8	34.2	23.1	26.1
Total Nitrogen	%	1.65	1.44	1.95	1.41	1.19	1.20
C:N Ratio	-	22.3	27.0	20.9	24.4	19.5	21.8
Phosphorus	%	0.63	0.42	2.25	0.13	0.28	0.20
Potassium	%	0.90	0.31	0.63	0.38	0.58	0.59
Sulfur	%	0.28	0.18	0.23	0.14	0.17	0.15
Magnesium	%	0.42	0.29	0.67	0.12	0.16	0.19
Calcium	%	2.14	1.60	7.08	0.38	0.79	0.80
Sodium	%	0.32	0.22	0.42	0.11	0.16	0.16
Iron	mg/kg	1926	2401	2336	274	4221	505
Copper	mg/kg	47	38	17	2	26	16
Manganese	mg/kg	211	74	126	102	99	84
Zinc	mg/kg	115	73	91	31	52	50
Boron	mg/kg	8	4	13	5	7	8

Know the Nutrient Content of the Compost Recipe

Nutrient content of the finished compost is a result of ingredients used. Managing the composting process begins with a good compost recipe; a mix of feedstocks in the right proportions. A good recipe or mix of amendments will result in a carbon-to-nitrogen ratio within a range of 15:1 to 35:1, moisture percentages within a range of 40 to 60%, and a particle size range between 0.1 to 2 inches in size. When the compost mixture is within these ranges, compost activity or rate of decomposition will be near maximum.

Spartan Compost Recipe Optimizer (2014) is a Microsoft® Office Excel application that simplifies planning compost recipes. The application uses Excel's Solver Add-In to automate the process of developing or formulating a compost recipe. The amounts of materials to be used in a compost mix are determined based on meeting the compost performance constraints or variables described above, while minimizing cost. Material constraints and costs can be set to limit the amount of specific ingredients incorporated in the compost mix. Performance constraints, or targets, are set for percent moisture, C:N ratio, and (or) particle size or bulk density. Both the material and performance constraints can be set to defaults or managed by the user.

Spartan Compost Recipe Optimizer is the only computer program available which automatically finds the least cost compost recipe that will actively decompose. Other computer spreadsheets available on the web for making compost recipes require that the user manually set amounts for amendments in a compost mix. This trial-and-error process can be time-consuming and confusing and does not provide the user with the tools or adequate information to reduce amendment costs. Spartan Compost Recipe Optimizer can be used for composting manures, organic and crop residues and animal mortalities. Using this program will lead to greater composting success and conservation of more nutrients and greater protection of the environment and animal and human health.

Spartan Compost Recipe Optimizer contains a large library of materials to be selected from when developing a compost mix. New user-defined materials are easily added to the library or the composition of any existing library material may be changed. This program is available for free from Michigan State University Extension at https://www.msu.edu/~rozeboom/.

Whole carcasses should be surrounded by a mixture of feedstocks that will readily decompose alone; without the nitrogen contribution of the animal tissue considered. The nutrient content of the carcass need not be considered in the initial recipe formulation, as the carcass is an anaerobic zone and the majority of nutrients reside unavailable to compost microbes until the soft tissue is substantially decomposed and the compost batch is mechanically stirred or mixed.

Nutrient Losses in Runoff and Leaching

Previous studies indicate that effluent leaving composting sites depends on rainfall amount, compost feedstocks (nutrient densities and relationships to one another, moisture content, porosity, and age), and season. Animal tissue, yard wastes, bovine manure pack, swine manure pack, food wastes, vegetable wastes, municipal refuse, and sewage sludge have been composted in studies where leachate and runoff quantities and (or) qualities were studied (Christensen and Nielsen, 1983; Cole, 1994; Morris et al., 1996; Ballestero and Douglas, 1996; Paré, 1997; Wilson et al., 2004; Glanville et al., 2006).

In the literature, effluent is the term used to describe any liquid leaving the compost site. Leachate is the term most frequently used to describe the water moving downward through the compost mixture and reaching the compost-pad interface. If the pad is soil, the water and nutrients therein may infiltrate that soil. Runoff is the water running off of the compost pile surface and off of the portion of the pad area around the compost and not covered by the compost mixture.

The nutrient content of effluent leaving compost and composting sites varies depending on rainfall amount, compost feedstock characteristics (nutrient densities, moisture content, porosity, and age), and season. The isolation of leachate, runoff, and condensate has been pursued with varied successes using lysimeters, physical barriers around the compost, U-shaped PVC troughs, and elevated platforms. Water byproducts leaving compost have contained varied amounts of nutrients such as C, P, K, NH_3-N, NO_3-N, and Cl-. Glanville and coworkers (2006) reported that total nitrogen losses may range from 10 to 40% of the total nitrogen in the original compost. The amount of loss was dependent on the nitrogen content and porosity of the feedstocks used (corn silage, ground corn stalks, or a combination of straw and manure); being greatest when manure was included.

Sanders and others (2010) collected effluent and estimated nutrient concentrations and volumes from uncovered, intact carcass, dairy cow mortality compost piles subjected to successive simulated 10.2 cm storm events. Nitrate-N leaching was greater in older compost and P leaching was greater in newer or fresher compost mixtures. Nutrient mass load in runoff accounted for 5.2% of total nitrogen, 4.9% of inorganic nitrogen, 3.3% of phosphorus, and 6.3% of potassium. The total load of N, P, and K collected in leachate represented for 8.7, 1.9, and 7.2% of the estimated initial nutrients in compost, respectively. The authors stated that they thought the nutrient loads were in a large part due to the timing of storm events with that of carcass collapse, the release of body fluids into the amendment, and the loss of a peaked or convex pile shape. Keener (2004) estimated the NH_3, P, and K loss in runoff from composting bovine manure windrows during storm events and reported ranges of 0.21 to 0.35, 0.19 to 0.29, and 1.07 to 1.57%, respectively. In this study researchers maintained windrow shape, so that more of the water from each storm was shed or flowed off of the compost and did not infiltrate.

Nutrient Losses as Emissions into the Air

The nutrients in compost, in particular nitrogen and carbon, are involved in the chemical processes which take place in the compost mass and can contribute significantly to emissions which are produced. The chemical decomposition of the feedstocks take place during both aerobic and anaerobic conditions which are bacterially mediated (Calderon et al., 2004; Fine et al. 1989). In the early aerobic phase of a compost system, aerobic organisms generate heat as a byproduct. This aerobic phase produces the most rapid period of organic decomposition. If compost is not disturbed (aerated by mixing intermittently or continuously) an anaerobic decomposition period will follow, with a slower rate of decomposition and less heat generated.

The primary byproducts of the aerobic phase of composting are heat, H_2O, and CO_2. Also produced, are varying amounts of CH_4, N_2O, and NH_3. Under anaerobic conditions and if sufficient NO_3 is available, the NO_3 can be used as an energy source for bacteria. Denitrification of the NO_3 produces N_2 and N_2O (Brown et al., 2009; Chadwick et al., 2011). This suggests that rapid decomposition under aerobic conditions (i.e., good or rapid activity), decreases the production of the N_2O greenhouse gas.

Brown and colleagues (2009) stated that covering piles with finished compost early in the composting process and subsequently incorporating that cover material into the compost will minimize the potential production of CH_4 and N_2O. Additionally, these authors recommend using a feedstock mixture with a C:N ratio greater than 30:1, using some type of aeration system, and keeping moisture content less than 55% as management practices which will also minimize the potential for the release of these greenhouse gases during composting.

Rozeboom and coworkers (2012) reported that the mass of CO_2 emitted per day tended to be greater ($P = 0.07$) with use of an in-vessel animal tissue composting system than with an open static pile system in the first three weeks of composting. The in-vessel system also emitted more ($P < 0.05$) Non Methanic Total HydroCarbons (NMTHC), NH_3, and SO_2, but less ($P < 0.05$) CH_4, NO, N_2O than the open static pile system.

This finding is consistent with that of Cuhls et al. (2008; referenced by Brown et al., 2009). Rozeboom and associates (2012) also reported that ammonia emitted during the early phase of composting was greater ($P < 0.05$) in-vessel than in the open static pile (78.326 grams per day vs 5.582 grams per day, respectively). This finding suggests that in the early stages of animal tissue composting an open static pile system would conserve nitrogen.

To date, total emissions during the entire animal tissue composting process or to a known point of maturity has not been reported. Thus, the importance of compost activity and compost system remains unknown. It is not known if the speed of the composting process in the primary phase results in less curing time and less total emissions to finished maturity of the compost. If slower activity throughout the entire composting process retains NH_3 but increases the total N_2O and CH_4 emitted, then management to maximize activity would be justified.

Conclusions

Considering the price pressure of inorganic fertilizers in recent years, the fertilizer value of animal tissue compost is worth greater attention. Historically compost has been valued mostly for improving physical and biological soil conditions. In the future, the animal tissue composting process must be managed to retain nutrients. Formulating the correct feedstock recipe becomes critical for maximizing decomposition, and for minimizing aerosolization of nutrient. Management will also be required to prevent nutrient loss in effluent.

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