TECHNICAL NOTE

Suitability of sunflower-hulls-based turkey litter for on-farm turkey carcass composting

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Rahman, S. 2012. **Suitability of sunflower-hulls-based turkey litter for on-farm turkey carcass composting**. Canadian Biosystems Engineering/Le génie des biosystèmes au Canada **54**: 6.1-6.8. Environmentally safe disposal of turkey carcasses is vital to a farm's bio security and prevention of disease outbreak. Carcass disposal by on-farm composting is considered a viable mortality management option. In this study, sunflower-hulls-based (SHB) turkey litter was used to examine the suitability of on-farm carcass composting under North Dakota climatic conditions.

This study was conducted at a turkey farm in North Dakota, USA. The farm raised four flocks of 35,000 to 40,000 turkeys per flock per year and each flock was approximately six to seven weeks apart in age. The mortality rate for this farm was very low i.e., <1%. The static piles were prepared using a front-end loader. A base layer of 0.30 m was prepared with turkey litter removed from the barns between flocks. One layer of turkey mortalities were placed on top of the base layer and were covered with another 0.30 m layer of litter. In all trials, dead turkey/litter ratio (weight basis) was 1:3. Hobo data loggers were placed at predetermined depths and locations to monitor temperature changes continuously throughout the composting process. Litter samples were collected before, during, and after final composting for determining carbon (C), nitrogen (N), phosphorus (P), pH, fibers, electrical conductivity, and moisture content. Compost maturity tests were performed during and following completion of active composting process.

Overall, SHB turkey litter was able to sustain temperatures of 55°C for 3-10 days during composting even though pile moisture content and carbon: nitrogen (C:N) ratio were lower than the recommended range of 40-65% and 25-30:1, respectively. A sustained temperature of 55°C is considered enough to destroy most pathogens. However, the normal practice of composting for 40-65 days was not enough to obtain matured compost due to high percentages of fibers such as cellulose, hemicelluloses, and lignin content in sunflower hulls. Therefore, the compost mix obtained from a finished pile may be reused for the next pile for complete degradation. Turning of the compost pile can be delayed and water can be added periodically to compensate pile moisture losses, eventually improving degradation of sunflower hulls and carcasses in turkey mortality compost piles. **Keywords**: turkey mortalities, turkey litter, composting, sunflower hulls, North Dakota.

L'élimination des carcasses de dindes de façon responsable envers l'environnement est un aspect vital à la biosécurité d'un élevage et à la prévention de maladies. L'élimination des carcasses par le biais de compostage sur le site même de la ferme est considéré comme étant une option viable pour la gestion des mortalités. Pour cet étude, un mélange de litière pour dindes à base d'écales de graines de tournesol (SHB) a été employé afin d'examiner la viabilité du compostage de carcasses à la ferme sous des conditions climatiques du Dakota du Nord.

Cette étude a été effectuée sur une ferme d'élevage de dindes situé au Dakota du Nord, aux États-Unis. Cette ferme faisait quatre élevages de dindes par an, allant de 35 000 à 40 000 dindes par élevage et chaque élevage avait entre six et sept semaines de différence d'âge entre eux. Le taux de mortalité pour cette ferme était très bas de <1%. Les tas de compost testées ont été préparées en utilisant un chargeur frontal. Une couche de base de 0,30m a été préparée avec de la litière des dindes recueillie des étables entre les élevages. Une couche de carcasses de dindes a ensuite été placée par-dessus la couche de base, suivie d'une autre couche de litière de 0,30m d'épaisseur. Pour tous les essais, le ratio carcasses de dindes/litière (sur une base pondérale) était de 1:3. Des enregistreurs de température HOBO ont été enfouis à des endroits et profondeurs prédéterminés afin de mesurer les changements de température de façon continue pendant la totalité du processus de compostage. Des échantillons de litière ont été recueillis avant, durant, et après le processus de compostage afin de déterminer le contenu en carbone (C), azote (N), phosphore (P), fibres, le pH, la conductivité électrique, et la teneur en eau. Des tests de maturité du compost ont été effectués durant le processus actif de compostage et après que celui-ci soit complété.

En général, la litière pour dindes SHB a pu maintenir des températures de 55°C durant une période de 3 à 10 jours malgré le fait que la teneur en eau et le ratio de carbone:azote (C:N) étaient plus bas que les plages recommandées, qui sont de 40-60% et de 25-30:1 respectivement. Une température maintenue à 55°C est considérée comme étant assez élevée pour détruire la majorité des pathogènes. Toutefois, le processus de compostage normal d'une durée de 40 à 65 jours n'était pas suffisant pour obtenir un mélange de compost mature, ce qui est attribuable au pourcentage élevé de fibres, tels que la cellulose, l'hémicellulose et la lignine contenue dans les écales de graines de tournesol. Le mélange de compost peut donc être réutilisé dans le prochain tas afin que le mélange se décompose complètement. Le retournement du tas de compost peut être retardé et de l'eau peut être ajoutée périodiquement afin de compenser pour la perte d'humidité ce qui accélèrerait la décomposition des écales de graines de tournesol et des carcasses dans les tas de compost de carcasses de dindes. **Mots clés** : Mortalités de dindes, litière de dindes, compostage, écales de graines de tournesol, Dakota du Nord.

INTRODUCTION

Mortality losses are a normal part of turkey production. Producers may have losses due to disease, accidents, or inter-animal competition. It is the responsibility of the producer to dispose of these mortalities in an environmentally acceptable manner. Safe disposal of carcasses is an important issue for day-to-day routine management of stock mortalities (Wilkinson 2007) and to prevent animal disease transmission and protect air and water quality (Xu et al. 2007). Therefore, carcass disposal remains one of the major challenges facing poultry producers.

Most states have regulations relating to the disposal of livestock and poultry mortalities. North Dakota regulations require farmers to manage their mortality in an environmentally sustainable manner and have identified composting as a safe disposal method. As a result, some producers want to adapt composting as a best management practice for managing on-farm mortalities, however, little scientific information exists on mortality composting under North Dakota climatic conditions. Carcasses alone are not suitable for proper composting due to their high N content. It is necessary to add co-composting materials as carbon sources to balance the C:N ratio along with moisture (Kalbasi et al. 2005). In addition, more research is needed on how the co-composting material is likely to perform when routine or emergency disposal of carcasses occurs. Typically, in turkey carcass composting, turkey litter is used as co-composting material and physicochemical characteristics of turkey litter vary depending on bedding materials and feed rations used.

Bedding materials are typically selected based upon their availability locally and their carbon content may vary widely. For example, in Iowa oat hulls are typically used (Li et al. 2008) and in Minnesota wood shavings are used as bedding (Shah et al. 2009). However, in North Dakota sunflower hulls are typically used for bedding in turkey production facilities. Composting of sunflower hulls has received little attention probably due to the relatively inert nature of the hulls (Conghos et al. 2006). However, adding organic nitrogen (i.e., turkey litter) to sunflower hulls might balance the C:N ratio for more efficient composting. Typically sunflower hulls have a low moisture content (<10%) and low C:N ratios (65-80) (Conghos et al. 2006) compared to other organic sources, but provide an excellent source of bedding material due to their high water absorbency. Similarly, the C:N ratio of turkey litter is typically low and varies widely 16:1 (NRAES 1992) to nearly 10:1 (Ahn et al. 2008). Whereas C:N ratio in turkey carcass is about 5:1 (NRAES 1992). The C:N ratio is an important factor affecting compost quality (Huang et al. 2004) and it is recommended to maintain a C:N of 25-30:1 (NRAES 1992) for successful composting. However, producers seldom add other carbon sources during composting mortalities with litter from their turkey facility.

Although, carcass composting is not new, limited information is available about the suitability of SHB turkey litter as a co-composting material for turkey carcass composting. For effective composting, sustained temperatures of more than 65°C are considered sufficient to kill most types of weed seeds (Churchill et al. 1995), while continuous high temperatures (55°C) for 3 days is needed to destroy most pathogens and viruses (Kalbasi et al. 2005; Payne and Pugh 2009). Therefore, the objective of this on-farm research was to assess whether sunflower hulls based turkey litter were suitable for composting carcasses without adding any additional carbon source. Specifically, this study focused on on-farm turkey carcass composting under North Dakota climatic conditions and management practices and assessing whether current on-farm composting processes using SHB turkey litter were suitable for raising compost temperatures to sufficient levels for pathogen destruction. As well, physical and chemical changes during on-farm turkey carcass composting were monitored.

MATERIALS and METHODS

This study was conducted on a turkey farm in North Dakota (4603'32.97" N and 9657'14.98" W) from 23 July, 2009 to December 15, 2009. During the study period, average ambient temperature, rainfall, relative humidity (RH), and wind speed ranged from -12 to 20°C, 56 to 150 mm, 50 to 76%, and 2.6 to 4.0 m/s, respectively. The farm had a capacity of 35,000 to 40,000 tom turkeys (males) at any time. Typically, this farm raised and finished four flocks each year in the grow-finish barn and the duration of each flock was 16-17 weeks. Birds at five weeks of age were moved from the brooder barn to grow-finish barn and the mortality rate for this farm was very low i.e., <1%. Caked litter (roughly 0.05 m of excessively wet litter) was removed after each flock and fresh bedding (sunflower hulls) was added before placement of the next flock. Some typical properties of sunflower hulls used in this turkey farm are listed in Table 1. Caked litter is typically used as a co-composting material for carcass composting; otherwise, it is stored and applied to fields as a fertilizer per the farm nutrient management plan.

Compost pile preparation

Due to low mortality, it was not possible to prepare three static piles at the same time, but at different time during each trial. As a result, out of three piles, only one pile was sampled and monitored assuming that all piles would behave the same way since same base material and similar carcass and litter ratio 1:3 (w/w) was used. Each pile was prepared (2.5 m×2.1 m×1.0 m) under a covered shed using a front-end loader. The base layer (0.30 m) was prepared with turkey litter. Turkey mortalities were placed on top of the base layer and were covered with another layer (0.30 m) of turkey litter (Fig. 1a). No additional carbon source was added to adjust the C:N ratio during the composting time. In this study three trials of turkey carcass composting were conducted. Trial-1 was carried out

Table 1. Moisture content of compost pile at different dates in each trial

Date	Time, day	Moisture, %
Trial-1		
7/23/2009	1	35.67
7/29/2009	7	35.40
8/13/2009	22	27.61
9/1/2009	41	43.84
Trial-2		
9/1/2009	1	46.93
9/14/2009	14	51.53
9/28/2009	28	40.58
10/12/2009	42	41.90
Trial-3		
10/12/2009	1	45.20
11/5/2009	24	49.30
11/24/2009	43	45.62
12/15/2009	64	38.92

between 7/23/09 to 09/01/09, trial-2 between 09/01/09 to 10/12/09, and trial-3 was between 10/12/09 to 12/15/09. During the first two trials (trial-1 and trial-2) compost pile surfaces were dry and water was sprayed occasionally using a hose on the compost pile surface the day before a pile turning. Occasionally, on-spot pile moisture content was checked using a Delmhorst 0.91 m hay probe (Professional equipment, LLC, Janesville, WI) to get instant pile moisture content and compost pile samples were collected during pile turning for moisture content analysis in laboratory.

During a pile preparation, loggers (HOBO Pro V2 T/RH, Onset Computer Corporation, Bourne, MA) were placed at the bottom (0.25 m from the bottom of a pile), center, and just below the top layer (0.15 m from the top) of a pile to monitor hourly temperature changes continuously throughout the composting process (Fig. 1b). During the trial-1, the first pile turning and thorough mixing were done between 7-10 days of pile initiation, thereafter all pile turning were done based upon temperature lowering of a pile (Fig. 2). A front-end loader was used for turning. During turning of a compost pile,

(a) (b)

Fig. 1. a) Static compost pile preparation and b) HOBO Pro V2 T/RH sensors for monitoring compost pile temperature

Table 2. Chemical properties of sunflower hulls and turkey litter

Parameters	Sunflower hulls	Turkey litter
Moisture (%)	13.5	34.01
pH	6.15	8.33
EC (dS/m)	2.53	6.38
TOC (%)	45.80	34.01
TN (%)	0.68	2.25
C:N	67:1	15:1
Cellulose (%)	65.76	45.57
Hemicellulose (%)	16.54	6.77
Lignin (%)	21.79	8.87
Ash content	4.56	12.93

temperature data loggers were removed, the pile was re-formed and sensors were reinstalled to their original depths.

Compost pile sampling and monitoring

In this study, each compost pile remained active for 41-64 days depending upon the ambient temperatures, and monitoring was terminated according to the normal practice of the producer when no visible carcass flesh was noticed. Thereafter, pile was transferred from the covered barn to outside of the shed for curing. During compost pile preparation and pile turning, 7-8 random composite samples (each composite sample prepared from 8-10 individual samples) were taken for carbon C, N, P, pH, and moisture content analysis. On sample collection day, a well-mixed representative sample was oven dried at 105ºC for 24 hrs for moisture content determination. Also, sub-samples were taken to measure pH and conductivity in duplicate. The composite samples were sent to the Soil and Water Environmental lab at North Dakota State University (NDSU) where samples were oven dried and homogenized by grinding in a Willey mill to pass through a 1 mm sieve. Total C was determined using a SKALAR Primacs TOC analyzer (Skalar Inc, Buford, GA, USA), whereas N and P were determined as per standard methods (APHA 2005). The pH of compost samples was measured with a pH probe by preparing water to compost ratio of 10:1(Sivakumar et al. 2007). Cellulose and hemicellulose were determined using the ANKOM method (ANKOM Technology, Macedon, NY) and lignin was determined using the AOAC Method 973.18.

RESULTS and DISCUSSION

Compost pile moisture

The initial moisture contents of compost trials -1, -2, and -3 at day zero were 35.6, 46.9, and 45.2%, respectively (Table 1). Moisture content of piles in each trial decreased towards the end of the composting period, except trial-1 where by day 22 since the inception of composting, the pile moisture dropped to about 27% and water had to be added to the pile. The average pile moisture contents (Table 1) for trial-1, trial-2, and trial-3 were 35.6, 45.2, and 44.7%, respectively. These averages were on the lower end of the recommended moisture range (i.e., 40-65%).

Moisture content during composting is an important environmental variable as it provides a medium for the transport of dissolved nutrients required for metabolic and physiological activities of microorganisms (Ahn et al. 2008; Liang et al. 2003). In this case, low moisture content during on-farm carcass composting was not a limiting factor for carcass decomposition, however, low moisture content during composting could slow-down the biological process, thus resulting in a physically stable but biologically unstable compost material (Bertoldi et al. 1983; Liang et al. 2003).

The sunflower hull in the turkey litter is composed of fibers (i.e., cellulose, hemicelluloses, and lignin) and degradation of fibers is highly dependent on availability of water and oxygen (Conghos et al. 2006). At the end of the carcass composting monitoring period, carcass flesh biodegraded and it was not visible, but sunflower hulls were not completely degraded, which was likely due to high cellulose, hemicelluloses, and lignin content (Table 2), as well as low moisture content in compost pile (Table 1). It might be feasible to continue using non-degraded sunflower hulls from a finished carcass composting pile as base materials for a new composting pile for complete degradation of co-composting material, as observed and suggested by others composting poultry mortalities with straw (Gonzalez and Sanchez 2005). An addition of moisture would likely increase degradation of co-composting materials, which would result in rapid carcass degradation rate, increased heat generation, and pathogen destruction (Ahn et al. 2008), but producers often don't apply additional moisture. Liang et al. (2003) found that 50% moisture content seems to be the minimal requirement for rapid increase in microbial activities in an active compost pile. Therefore, it is important to begin a compost pile with optimum recommended moisture content (>50%) to expedite composting process and to obtain quality finished compost product.

Compost pile temperature

Temperature profiles of each trial differed considerably (Fig. 2). Following compost pile establishment, pile temperatures exceeded the threshold temperature values (55°C; where most pathogens may be destroyed) within two to three days of compost pile preparation and steadily increased to 60-65°C and sustained that temperature for a few days. Thereafter temperatures dropped between 31 and 53°C depending on pile turning and ambient temperature for each trial. Following the first pile turning anywhere from 7 to 24 days after inception of composting during a trial, temperature increased steadily to as high as 67°C and remained above the threshold temperature of 55°C for several days. During compost trial-1, summer time average ambient temperatures fluctuated within a narrow range, however, during trials-2 and -3, fall and winter average ambient temperatures fluctuated widely, contributing to greater pile temperature fluctuations for trials -2 and -3 as compared to trial-1 pile temperatures. This is especially the case for trial-3 when ambient temperature ranged from -19 to 12°C, preventing the pile temperature to reach above 55°C for a sustained time period. Gonzalez and Sanchez (2005) observed that cold ambient temperatures prevent desirable high temperatures within a compost pile.

In this study, during the first active composting phase, sustained pile temperatures of 55°C or higher were achieved and maintained for more than three days irrespective of weather conditions, which would ensure the pathogen destruction as reported by others (Murphy et al. 2004). The highest number of days for sustained temperature of 55°C was achieved following turn 1, which was likely due to pile aeration that enhanced microbial activity. Following 2nd and 3rd turning, secondary and tertiary temperature peaks occurred and passed the threshold value (55°C), but the duration of sustained temperature of 55°C was much shorter than the first pile turning. As the organic matter and microbial activity became more stabilized, the organic matter decomposition rate and temperature decreased gradually to ambient (Petric et al. 2009). In all trials irrespective of ambient temperature, sunflower hulls-based turkey litter maintained a temperature of 55°C for at least three consecutive days indicating the bio-safety of composting as also indicated by others (Sivakumar et al. 2008). A similar conclusion was also drawn by Ahn et al. (2008) that wood shavings-based turkey litter sustained temperature required for pathogen destruction.

Total N, total C, and C:N ratio of compost pile

Changes in total N and C:N ratio during the composting process are listed in Table 3 and averages of trials are listed in Table 4. During the entire monitoring period (42-65 days) total carbon (C) content in composting pile decreased in trial-1 (by 8.06%) and trial-2 (8.65%), except trial-3 (1.44%) when carbon values were compared with pre-composting and averaged over all post-composting samples (Table 3). These results were in agreement with

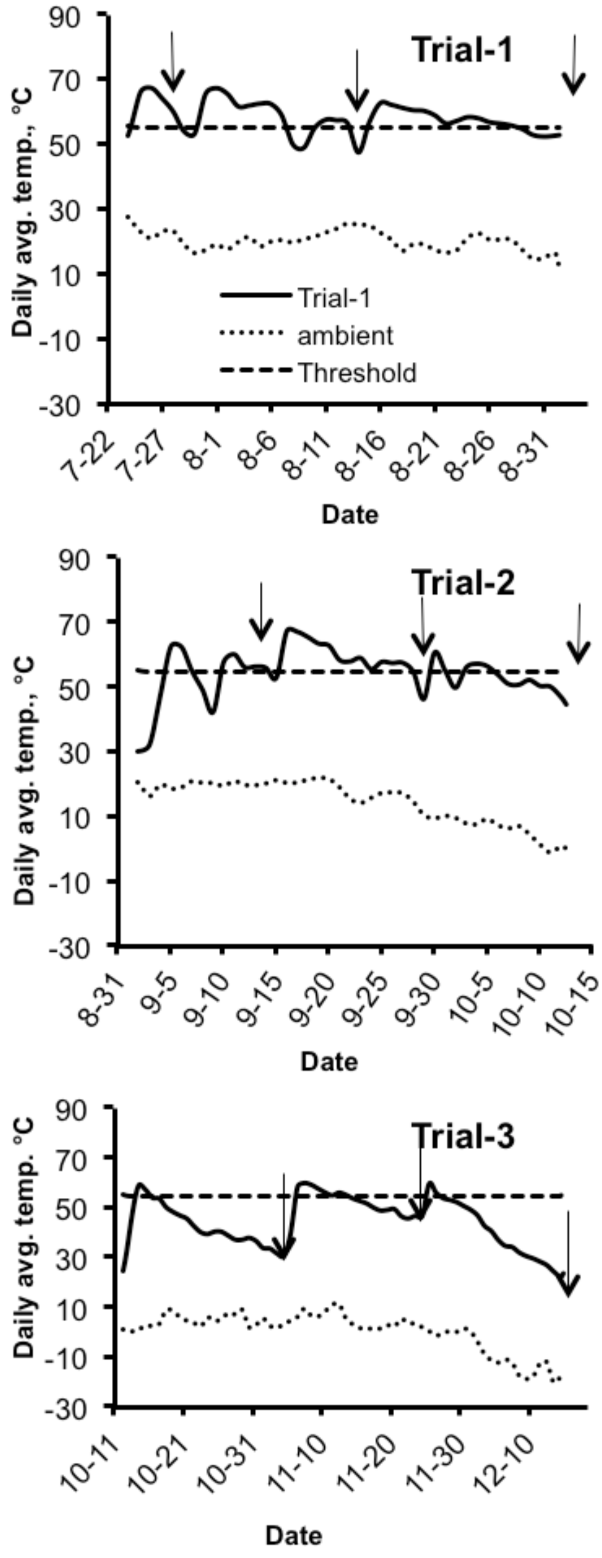

Fig. 2. Temperature profile of compost piles during different trials. Down arrows indicate pile-turning events.

Table 3. Chemical analysis of the composting samples during each trial and sampling date

Date	Time, day	C, %	N, %	P_2O_5, %	K_2O, %	C/N ratio	pH	Electrical conductivity (EC), dS/m
Trial-1								
7/23/2009	1	37.72	2.85	1.98	1.85	13.24	-	-
7/29/2009	7	34.27	2.43	1.92	1.14	14.10	8.07	6.50
8/13/2009	22	34.84	2.48	1.76	1.29	14.05	8.46	5.23
9/1/2009	41	34.92	2.52	1.97	1.40	13.86	7.83	6.59
Trial-2								
9/1/2009	1	35.45	2.21	2.09	1.45	16.04	8.37	6.88
9/14/2009	14	32.95	2.17	2.49	1.39	15.18	8.05	7.42
9/28/2009	28	32.35	2.12	2.45	1.07	15.24	8.30	6.52
10/12/2009	42	31.85	2.17	2.96	1.32	14.68	8.36	6.00
Trial-3								
10/12/2009	1	33.82	2.11	2.16	1.03	16.03	8.25	6.41
11/5/2009	24	32.99	2.01	2.36	1.34	16.41	8.42	7.50
11/24/2009	43	34.31	2.02	2.03	1.48	16.99	8.56	5.95
12/15/2009	64	32.69	1.90	2.10	1.59	17.21	9.21	5.39

Conghos et al. (2006), who found that carbon losses could occur between 4-28% during sunflower hulls composting over a period of 100 days. Overall, total N content during composting decreased by 13.0, 2.5, and 6.33% in trial-1, trial-2, and trial-3, respectively, as compared to the total N in pre-compost samples.

Like total N, C:N ratio also fluctuated during composting (Table 3). Reduction of C:N ratio during composting process, however, is a good indication of digestion of carbon sources by microorganisms (Kalbasi et al. 2005). The C:N ratio increased by 5.8 and 5.25% in trial-1 and trial-3, respectively, while its ratio decreased in compost trial-2 by 6.28%. The decrease in total C was likely due to oxidation of C to CO_2 by the microorganisms during composting (Tiquia et al. 1998). High pH (>8.0) and low C:N ratios (i.e., 13:1 to 16:1) might have contributed to N losses due to NH_3 volatilization, although NH_3 volatilization loss was not measured which agrees with the work of Tiquia and Tam (2000). Although it is suggested in the literature that an initial C:N ratio of 25-30 is needed for composting, low initial C:N ratio was not an impediment to carcass decomposition during composting. However, increased C:N ratios may have resulted in increased internal temperature of piles, rapid carcass decomposition, and enhanced sunflower hulls degradation.

pH and electrical conductivity (EC)

The pH and electrical conductivity are two important parameters for using composted materials as organic soil amendment since the soil physical, chemical and microbial reactions are influenced by these two parameters (Banegas et al. 2007). pH values fluctuated and varied between trial-1 and trial-3, but not in trial-2 (Table 3). pH values ranged from 7.83 to 9.30, which were consistent with other findings (Ahn et al. 2008). Ammonia volatilization increases with an increase of pH (DeLaune et al. 2004). Ekinci et al. (2000) found that NH_3 volatilization loss decreased rapidly when pH was below 7.0 and increased rapidly for pH above 8.0. Throughout this study, average compost pile pH was between 8.05 and 9.30, except one occasion when pH dropped to 7.83 (Table 3). Overall, pH of compost changed slightly during the composting process. This was likely due to mixing of decomposed organic matter and carcasses.

The EC values ranged from 5.23 to 7.42 dS/m (Table 3), which were higher than values reported by (Conghos et al. 2003; 2006). High EC values were likely due to turkey

Table 4. Physico-chemical characteristics of the composting end products averaged over the entire monitoring period for each trial (± standard deviation)

Trial #	C, %	N, %	P_2O_5, %	K_2O, %	C/N ratio	pH	EC dS/m
Trial-1	35.44 ±1.55	2.57 ±0.19	1.66 ±0.59	1.42 ±0.31	13.81 ±0.40	8.12 ±0.32	6.11 ±0.76
Trial-2	33.15 ±1.60	2.17 ±0.04	2.50 ±0.36	1.31 ±0.17	15.28 ±0.56	8.27 ±0.15	6.71 ±0.60
Trial-3	33.45 ±0.75	2.01 ±0.09	2.16 ±0.14	1.36 ±0.24	16.66 ±0.54	8.61 ±0.42	6.31 ±0.89

litter and decomposed carcasses. Compost EC is of great importance from an agronomic viewpoint since it can be a limiting factor for plant growth and seed germination (Banegas et al. 2007). Electrical conductivity was high but below the values (<8 dS/m) considered detrimental for plant growth and seed germination. Others have reported the compost EC values greater than 4 dS/m as an indication of phytotoxicity, when composts are considered as a growing substrate (Francou et al. 2005) for plants. In this study, compost EC value was greater than 4 dS/m.

Nutrients characteristics

Chemical analysis of composting samples at different times and trials are listed in Table 3 and their averages for each trial are listed in Table 4. Nitrogen (N) concentration of compost piles decreased by 13.0, 2.5, and 6.33% in trial-1, trial-2, and trial-3, respectively, when compared with the pre-compost samples and averaged over all post-composting samples. In trial-1, N loss was greater than the other trials due to high initial nitrogen content. This N reduction is, however, was much lower than reported elsewhere (Tiquia and Tam 2000), which was likely due to blending of turkey litter and sunflower hulls. Others also drew a similar conclusion that a blend of poultry litter and sorghum straw can reduce N losses during composting when N loss during composting was compared with and without blending with straw (Amanullah 2007). Nutrient value of compost as indicated by the N, P_2O_5, and K_2O content were in agreement with others findings (Haque and Vandepopuliere 1994). Typically, composting yields more stable sources of N than the organic N in fresh litter (Preusch et al. 2002), which would mineralize more slowly than the litter N (Haque and Vandepopuliere 1994).

Phosphate concentration fluctuated minimally during the carcass-composting period and increased slightly, except trial-1. In trial-1, P_2O_5 concentrations decrease by 4.7%, but increased by 25.97 and 0.15% in trial-2 and trial-3, respectively. Like phosphorus, K_2O concentrations also fluctuated during composting period. Phosphate and K_2O content fluctuations were likely due to the overall reduction in dry matter resulting from the rapid loss of carbon as carbon dioxide (CO_2) and nitrogen as NH_3 during composting, although CO_2 and NH_3 were not measured. Similar results were also reported by others (Haque and Vandepopuliere 1994; Sommer 2001).

CONCLUSIONS

During the composting period, moisture content and C:N ratio of compost piles were lower than the recommended moisture content and C:N ratio, which might affect carcass flesh and bone decomposition. On-farm composting of turkey carcasses with sunflower hulls-based litter for a duration of 40-65 days was not enough to obtain a mature compost product, but composting carcasses in northern climatic conditions is still viable, since sunflower hulls-based turkey litter was able to sustain temperatures of 55°C and above for several days as required for pathogen destruction of most disease-related mortality composting. Due to low pile moisture content, compost pile should be turned less frequently and water can be added to the pile to improve degradation of sunflower hulls and carcasses. The finished compost product is an excellent source of nutrients and can be used as organic fertilizer to meet crop nutrients requirement.

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