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CHEMICAL CHANGES DURING COMPOSTING OF POULTRY WASTE WITH COIRPITH WASTE AND SUGARCANE TOP

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Abstract: Composting of dead birds with cage layer manure (CLM) and low cost carbonaceous materials like 'coir pith waste' and 'sugarcane top' was carried out to study the feasibility of composting. Based on the C:N ratio of the ingredient, the compost recipes were formulated. Composting was carried out by sequential layering of dead birds with manure substrate and carbon source. Treatment mixture with CLM alone (T_5) had higher pH value (8.48 and 8.44 during primary and secondary stage, respectively). But treatment mixture with dead birds (T_1 and T_2) had lower pH (7.45 and 7.85 for T_1 and T_2 during primary stage and 7.81 and 7.58 for T_1 and T_2 during secondary stage, respectively). EC and TDS had decreasing trend from primary stage to secondary stage. The total organic matter content was reduced at the end of secondary stage and ranged between 30.31 ± 1.06 and 32.99 ± 0.69 per cent. There was a reduction in total organic carbon content at the end of secondary stage in all treatments, (expect T_5) which ranged between 17.58 ± 0.61 and 19.13 ± 0.40 per cent. The N content in the finished compost ranged between 10.68 and 12.65 g/kg and maximum loss of nitrogen was noticed in T_1 (39.18 per cent), T_2 (39.06 per cent) and T_5 (41.51 per cent). At the end of composting process the C:N ratio of different treatment mixtures did not differ significantly and it ranged between 14.36:1 and 17.37:1. The C:N ratio below 20:1 ensured compost stability.

The mean Ca, P, and K content of all treatment mixture ranged between 54.59 to 68.63 g/kg, 19.44 to 32.49 g/kg and 23.43 to 37.15 g/kg, respectively.

Keywords: dead birds; composting; chemical changes.

Introduction

Larger production units with higher bird density generate large quantities of waste, which includes a mixture of excreta (manure), bedding material or litter, waste feed, dead birds, broken eggs and feathers. Safe disposal and utilization of such waste is essential to

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ensure bio-safety. Among the farm waste, handling of dead bird is a major problem to the poultry growers. An alternative and economically feasible method of disposal of poultry waste is composting. Composting is a natural biological decomposition process that takes place under aerobic and thermophilic conditions (Mukhtar *et al*., 2004).

Materials and Methods

The dead birds composting experiment was carried out at the Livestock Farm, Department of Livestock Production and Management, Veterinary college and Research Institute, Namakkal, Tamil Nadu, India.

Mini composter

All the four sides of the bin were closed with 4 inch size wooden plank fixed apart with an air space of 2 inch (Donald *et al*., 1996 and Sivakumar *et al*., 2007). A total of 10 such bins were arranged in two rows inside a tile roofed shed to protect the bins from rain and sun light.

Selection of ingredients

Dead birds were obtained from commercial poultry farms and stored in the deep freezer at -20˚C till sufficient carcasses were available for uniform filling. Cage layer manure (CLM) was collected from commercial high - rise layer farms. The low cost carbon sources like 'coir pith waste' and 'dried sugarcane top' were collected from coir pith industry and local farmer’s field, respectively. Dried sugarcane top was chaffed to a length of 2 to 3 inches for ease of filling the compost bin, whereas the coir pith waste was used as such.

Chemical properties of compost sample

Dried samples were ground in a high speed grinding mill to pass through 2 mm sieve. An aqueous solution of compost sample mix was prepared (1:10 W/V compost-water extract) and pH was measured (Tiquia and Tam, 2002) using digital pH meter (Systronic make MKVI).

EC and TDS were measured (Tiquia and Tam, 2002) using Conductivity - TDS meter (Systronic make $308^{\mu c}$ model) by preparing 1:10 W/V compost - water extract.

Total ash content was analyzed by assessing loss on ignition in muffle furnace at 550˚C for 5 hours (Allison, 1965). Total organic matter (TOM) was calculated by gravimetric loss on ignition produced by ashing the samples in a muffle furnace for 24 hours at 430˚C (Navarro *et al*., 1993).The total carbon was calculated from total organic matter value using the conventional “Van Bemelem Factor” of 1.724. The weight loss on ignition was divided by 1.724 to give the percentage of total carbon (Navarro *et al*., 1993 and Lawson and

Keeling, 1999). Total Kjeldahl nitrogen was estimated by digesting the compost sample in concentrated sulphuric acid and by distillation and trapping the ammonia in 0.1N sulphuric acid titrated against standard 0.1N sodium hydroxide solution (AOAC, 1995).Carbon nitrogen ratio was calculated based on the total carbon and total Kjeldahl nitrogen concentration (Zhu *et al*., 2004).The compost samples were analyzed for calcium and potassium using Flame photometer as described by Jackson (1973). The concentration of phosphorous was analyzed using spectrophotometer (Vanado- molybdate yellow colour method) as described by Jackson (1973).

The data thus collected were subjected to a one-way analysis of variance. The analyses were performed by data analysis using window 2003 computing package.

Result and Discussion

pH

The pH of T_1 and T_2 are near neutral in the finished dead bird compost (7.81 and 7.58, respectively) and in their respective control it was slightly alkaline (8.04 for T_3 and 8.61 for T_4). In case of T_5 the pH was 8.44 (Table 1). This was in agreement with Kumar *et al*. (2007) who reported a pH range of 7.27 and 8.53 in the finished dead bird compost, which indicated that organic matter were stabilized (Tiquia and Tam, 2002).

Electrical conductivity and Total dissolved salts

The degree of salinity of compost material, reflects EC value (Zhang and He, 2006) and in the present experiment the EC and TDS showed a decreasing trend from the end of primary stage to secondary stage (Table 1). In the finished compost the EC ranged between 2.52 and 3.56 mS/cm in all treatment and control groups. Similar to EC, the TDS value also reduced from primary to secondary stage (2.13 - 2.70 ppt to 1.34 -1.98 ppt). Kumar *et al.* (2007) reported that season had an influence on the EC and TDS value. They opined that EC and TDS values were higher in winter (6.84 to 7.42 mS/cm and 2.07 to 3.55 ppt, respectively) than in summer (3.95 to 4.79 mS/cm and 1.27 to 1.96 ppt, respectively). The observed values were lower than the reported values (Kumar *et al*., 2007).

Table 1. Mean (± SE) pH, electrical conductivity (mS/cm) and total dissolved salts (ppt) of compost samples

Treatment	End of primary stage						End of secondary stage					
	T_1	T_2	T_3	T_4	T_5	'F' value	T_1	T_2	T_3	T_4	T_5	'F' value
pH	7.45^{d} ± 0.06	7.85^{c} ± 0.08	8.29^{b} ± 0.05	8.26^{b} ± 0.05	8.48^{a} ± 0.02	54.77**	7.81^{bc} ± 0.06	7.58^{c} ± 0.07	8.04^{b} ± 0.08	8.61^{a} ± 0.13	8.44^{a} ± 0.03	27.67**
Electrical conductivity (mS/cm)	4.10^{bc} ± 0.17	3.93^{c} ± 0.17	4.84^{a} ± 0.30	4.78^{ab} ± 0.17	4.75^{ab} ± 0.16	4.71**	3.56^{a} ± 0.18	2.52^{b} ± 0.17	2.74^{b} ± 0.15	2.55^{b} ± 0.22	2.91^{ab} ± 0.21	5.01**
Total dissolved salts (ppt)	2.13^{b} ± 0.09	2.20^{b}± 0.10	2.64^{a} ± 0.18	2.70^{a} ± 0.09	2.70^{a} ± 0.10	5.99**	1.87^{ab} ± 0.12	1.98^{a} ± 0.28	1.40^{ab} ± 0.08	1.34^{b} ± 0.13	1.55^{ab} ± 0.12	3.10*

Figures with different small letters row wise differ significantly.
** - Significant at one per cent level (P< 0.01).
*- Significant at five per cent level (P< 0.05).

Total ash

In this study, the total ash content was increased from primary (60.95 to 66.21 per cent) to secondary stage (67.01 to 69.69 per cent), presented in Table 2. The rate of increase was between 2.30 and 12.91 per cent. The elevated total ash content might be due to the limestone used in the layer hen diet (Haque and Vandepopuliere, 1994) or collection and storage of CLM over the earth, might have led to higher sand and silica content (Sivakumar, 2006).

Table 2. Mean (± SE) total ash (%), total organic matter (%) and total organic carbon (%) of compost samples

Treatment	End of primary stage						End of secondary stage					
	T_1	T_2	T_3	T_4	T_5	'F' value	T_1	T_2	T_3	T_4	T_5	'F' value
Total ash (%)	65.59 ± 1.25	65.20 ± 1.86	66.21 ± 1.43	65.50 ± 1.41	60.95 ± 1.29	2.11^{NS}	67.82 ± 0.82	69.69 ± 1.07	68.95 ± 0.85	67.01 ± 0.69	68.82 ± 1.09	1.33^{NS}
Total organic matter (%)	34.40 ± 1.25	34.79 ± 1.86	33.78 ± 1.43	34.49 ± 1.49	39.04 ± 1.29	2.11^{NS}	32.18 ± 0.81	30.31 ± 1.06	31.05 ± 0.84	32.99 ± 0.69	31.18 ± 1.09	1.33^{NS}
Total organic carbon (%)	19.95 ± 0.73	20.18 ± 1.08	19.59 ± 0.83	20.00 ± 0.81	17.25 ± 1.96	1.43^{NS}	18.66 ± 0.47	17.58 ± 0.61	18.01 ± 0.49	19.13 ± 0.40	18.80 ± 0.63	1.34^{NS}

NS - Non significant

Total organic matter

TOM reflects the quantity of organic matter lost through microbial degradation and oxidation process. In this study, the TOM was reduced at the end of secondary stage (30.31 to 32.99 per cent). This might be due to loss of organic matter through microbial degradation (Tiquia and Tam, 2000 and Sivakumar, 2006).

Total organic carbon

There was a reduction in TOC content from primary stage (19.59 to 20.18 per cent) to secondary stages (17.58 to 19.13 per cent) in all treatments expect T_5 which showed an increasing trend (17.25 to 18.80 per cent) presented in Table 2. Similarly, reduction of TOC was reported by Haque and Vandepopuliere (1994) in CLM with poultry litter compost (31.6 to 26.6 per cent), Huang *et al*. (2004) in pig manure with saw dust (47 to 34 per cent). This reduction was mainly due to the loss of organic matter through microbial degradation (Kumar *et al*., 2007) or most of the carbon was evolved as CO_2 during composting (Haque and Vandepopuliere, 1994). Increasing TOC content in T_5 (CLM alone) might be due to improper composting because the initial C:N was not adjusted.

Total nitrogen

The main objective of composting is to reduce the N loss by NH_3 volatilization and conserving N by favouring N mineralization. From the results a clear trend could not be established in the N profile between different stages of composting but added carbon source exerted an influence on N conservation (Mohamed Amanullah, 2007). In the finished compost T_1 and T_3 showed an increasing trend (from 11.12 to 11.47 g/kg for T_1 and from 11.59 to 12.65 g/kg for T_3), in both the treatments where coir pith waste was the added carbon source. On the other hand in the treatment group with dried sugarcane top as carbon source (T_2 and T_4) showed a decreasing trend (from 11.99 to 11.45 g/kg in T_2 and from 11.81 to 11.28 g/kg in T_4) presented in Table 3.

Heavy loss of N was noticed from the initial value to end of first heating cycle (41.03 per cent in $T_{1,}$ 36.18 per cent in $T_{2,}$ 24 per cent in T_3, 22.50 per cent in T_4 and 12.43 per cent in T_5). The rate of reduction was in decreasing order from T_1 to T_5. The N volatilization was reduced in the secondary stage and showed an increasing trend in T_1 and T_3 which showed that the N was stabilized. During secondary stage the total N content was increased (3.1 per cent T_1 and 9.1 per cent in T_3) in the compost bins with coir pith waste as carbon source. In case of T_2 and $T_{4,}$ there was a reduction in total N (4.5 per cent). From the results it could be inferred that coir pith waste was better in N conservation than sugarcane top.

Over all, there was a reduction of 17 to 41.51 per cent in total N and heavy loss was noticed in T_1 (39.18 per cent), T_2 (39.06 per cent) and T_5 (41.51 per cent). Heavy loss of N (up to 33 per cent) during composting of poultry manure was reported by Hansen *et al*. (1989), Mahimairaja *et a*l. (1994). Das *et al*. (2002) reported heavy loss in N in hatchery waste compost (55.2 to 63.2 per cent) and Sivakumar *et al*. (2007) reported a loss of 18.5 to 22.91 per cent N in dead bird compost.

Table 3. Mean (± SE) total Kjeldahl nitrogen content (g/kg) and C:N ratio of compost samples

Treatment	End of primary						End of secondary					
	T_1	T_2	T_3	T_4	T_5	'F' value	T_1	T_2	T_3	T_4	T_5	'F' value
Total Kjeldahl Nitrogen content	11.12^b ± 0.40	11.99^b ± 0.43	11.59^b ± 0.42	11.81^b ± 0.71	15.99^a ± 0.44	16.02**	11.47 ± 0.75	11.45 ± 0.42	12.65 ± 0.45	11.28 ± 0.34	10.68 ± 0.52	1.94^{NS}
C:N ratio	18.20^a ± 0.92	17.16^a ± 1.12	17.31^a ± 0.16	17.19^a ± 0.95	10.82^b ± 1.13	7.24**	17.11 ± 1.21	15.59 ± 0.84	14.36 ± 0.48	17.16 ± 0.68	17.37 ± 0.99	2.10^{NS}

Figures with different small letters row wise differ significantly.
** - Significant at one per cent level (P< 0.01)
NS - Non significant

C:N ratio

The C:N ratio showed a reducing trend from initial to end stage of composting in all the treatment groups expect T_5. Even though there was a heavy loss in total N content during the composting process a proportionate loss in total organic matter and total carbon was noticed (Table. 3), which might be due to microbial decomposition. A C:N ratio below 20:1 was considered satisfactory for compost maturity (Hirai *et al*., 1983). In this experiment the C:N ratio in the finished compost ranged between 14.36:1 and 17.37:1 (Table 3), which indicated the stability of finished compost. Higher rate of reduction (from 23:1 to 7:1) in C:N ratio was reported by Cummins *et al.* (1993), Lawson and Keeling (1999) and Sivakumar *et al*. (2007) in dead bird compost.

When CLM alone was used as control (T_5), there was an initial reduction in C:N ratio upto the end of primary stage (from 12.72 : 1 to 10.82 : 1). Subsequently the C:N ratio was increased to a level of 17.37: 1 which might be due to heavy loss of N in T_5 (Das *et al.*, 2002 and Tiquia and Tam, 2002).

Plant nutrients

Calcium

The total Ca content showed an increasing trend from the primary to secondary stage of composting (Table 4). In the finished compost, the Ca content did not differ significantly between different treatment mixtures and it was numerically higher in the dead bird composts (T_1 and T_2) than their respective controls (T_3 and T_4). Over all, the Ca content had ranged between 54.59 and 68.63 g/kg. The loss of organic matter during composting process must be the reason for the increase in the Ca content in the finished compost. The results are comparable with the reported values of Kumar *et al.* (2007).

Phosphorus

Total P content was high in T_5 (32.49 g/kg) followed by T_4, T_2, and T_3 and least in T_1 (Table 4). The total P content in dead bird compost mixtures and their respective controls ranged between 19.44 and 25.85 g/kg, which were comparable with the reported values (18 to 34.8 g/kg) in various dead bird composts (Murphy and Carr, 1991, Cummins *et al.*, 1993, Lawson and Keeling, 1999, McCaskey, 1994 and Kumar *et al.*, 2007).

Potassium

Total K content was significantly higher in T_1, T_3, and T_5 (37.15, 33.07 and 29.95 g/kg, respectively) than T_2 and T_4 (23.43 and 27.42 g/kg, respectively). The high level of total K in the coir pith waste and dead bird might be the reason for the elevated level of K. Murphy and Carr (1991), Cummins *et al.* (1993), Lawson and Keeling, (1999), McCaskey (1994) and Kumar *et al.* (2007) also reported similar values in dead bird compost (18 to 38 g/kg).

Table 4. Mean (± SE) Calcium, Phosphorous and Potassium content (g/kg) of compost samples

Treatment	End of primary						End of secondary					
	T_1	T_2	T_3	T_4	T_5	'F' value	T_1	T_2	T_3	T_4	T_5	'F' value
Calcium (g/Kg)	31.18^{d} ± 1.37	35.59^{c} ± 0.86	36.97^{bc} ± 0.85	40.55^{ab} ± 0.59	41.11^{a} ± 1.05	16.87**	61.13 ± 3.73	65.59 ± 4.43	57.67 ± 3.65	54.59 ± 3.00	68.63 ± 4.47	2.14^{NS}
Phosphorous (g/Kg)	19.33 ± 1.53	16.05 ± 0.46	19.00 ± 0.93	16.56 ± 0.80	17.80 ± 0.89	2.13^{NS}	19.44^{c} ± 1.31	23.56^{bc} ± 1.86	20.58^{bc} ± 1.38	25.85^{b} ± 1.40	32.49^{a} ± 0.81	13.74**
Potassium (g/Kg)	26.33^{b} ± 0.55	15.62^{c} ± 0.95	30.60^{a} ± 0.85	24.45^{b} ± 1.45	31.66^{a} ± 0.48	47.61**	37.15^{a} ± 1.80	23.43^{d} ± 1.30	33.07^{b} ± 1.42	27.42^{c} ± 1.29	29.95^{bc} ± 1.62	12.17 **

Figures with different small letters row wise differ significantly.
** - Significant at one per cent level (P< 0.01)
NS - Non significant

Conclusions

To conclude that the composting process of poultry waste with coir pith waste was better in N conservation than poultry waste with sugarcane top and good microbial degredation.

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