Effect of different levels of Mg and P salts as struvite used in layer litter composting

R. Islam, M.A. Hashem, R.I. Khan, M.M. Rahman, M.M. Hossain and M.E. Haque[1]
Department of Animal Science, Bangladesh Agricultural University, Mymensingh-2202, Department of Animal Nutrition, Sylhet Agricultural University, Sylhet-3100, E-mail: hashem_mdabul@yahoo.com

Abstract: The present experiment was conducted to compare the different struvite composts made by incorporating different level of $MgCl_2$ and PO_4 salt in layer litter with the aim to produce slow releasing fertilizer and to reduce ammonia emission by precipitating ammonia into struvite for environmental control. The experiments were conducted in aerobic condition with different level of Mg and P salts in layer litter. To fulfill the objectives four treatments were made as follows T_0= Control, T_1= layer litter with 10% $MgCl_2$:KH_2PO_4, T_2= layer litter with 20% $MgCl_2$:KH_2PO_4, and T_3= layer litter with 30%$MgCl_2$:KH_2PO_4. The sample from composted materials was collected at 0, 10, 20 and 30 days of interval for pH, C/N ratio and proximate analysis. In each treatment there were three replications to minimize the experimental errors. At 0 day, significantly ($P<0.05$) higher CP content was observed in T_3 and the highest CF was observed in T_1 however the C/N ratio was the highest in T_0. At 10 days, significantly ($P<0.05$) highest DM and moisture content were observed in T_3 and T_1, respectively. However, the CP and CF content were significantly ($P<0.05$) higher in T_3 and T_2, respectively. The C/N ratio and p^H were also significantly ($P<0.05$) higher in T_0 than other treatment. At 20 days, CP and CF content were significantly ($P<0.05$) higher in T_3 and T_1, respectively. However, both the C/N ratio and pH were observed higher in T_0. At 30 days, the significantly ($P<0.05$) highest CP content was observed in T_3 however the C/N ratio and pH were the highest in T_0. So, addition of 30% Mg and PO_4 salts in layer litter composting, N retention as CP, pH and C/N ratio at the end of the composting period was in optimum condition. Therefore, addition of Mg and PO_4 salts are good to produce high-quality compost containing slow realizing fertilizer as struvite while simultaneously reduces malodors during composting.
Key words: Mg and P salts, Struvite, Layer litter, Composting.

Introduction

Commercial poultry industry is growing rapidly in Bangladesh and plays a key role in developing our socio-economic condition, however, it might also be a great threat to our environment due to improper management of their droppings. Layer hens produce 100-150g waste products per bird per day with 25% dry matter content (Taiganides, 1977). It contains about 28-30% crude protein out of which 36-50% is true protein (Bhattacharya and Taylor, 1975). Due to the lack of proper disposal system, a large amount of poultry manure and litters (feces with bedding materials) are creating environmental and health hazards and foul smell near and adjoining areas of the poultry farms. Moreover, some farmers are thrown poultry droppings into their fishpond without any treatment which cause water and soil pollution and transmit diseases to fish and other living things. As a result local communities are complaining against these poultry farms, which in the long run may become threat to the sustainability of poultry industries. There are many methods using disposal of poultry dropping, but not more effective and suitable at farmers' level of Bangladesh. Recently, a new strategy has been introduced in the composting process to reduce ammonia loss and to increase the agronomic value of the compost (Jeong and kim, 2001). It is introduced as struvite crystallization reaction in the compost mixture by adding water soluble Mg and P salts. Struvite is crystallized magnesium ammonium phosphate (MAP,$MgNH_4PO_4 \cdot 6H_2O$) with magnesium and ammonium phosphate in equal molar concentrations; it is formed under alkaline conditions. It is a mineral with a low specific gravity of 1.7. Struvite is sparingly soluble under neutral and alkaline conditions but readily soluble in acid (Chirmuley, 1994). It is a valuable slow-releasing fertilizer that is effective in acidic and hilly (sloppy) lands (Bhuiyan, *et al.,* 2008), is not flashed away by rainfall, and can also be successfully used in flooded areas. The struvite crystallization reaction in composting has a beneficial effect on the conservation of nitrogen. The formation of struvite crystals significantly reduces the gaseous loss of ammonia and resulted in a substantial increase in the ammonia contents of the compost up to 1.5%.

Currently, limited research has been conducted on the effects of Mg and PO_4 supplements on composting. Further research is required to determine the suitable level of Mg or Ca salts and PO_4 for struvite crystallization during composting. In Bangladesh, there are very few studies on composting by using layer litters but no study yet been done on struvite compost. Therefore, the large-scale production of struvite from animal manure and wastewater and its effective application for crop production can help make the environment safe and pollution-free Bangladesh.

Materials and Methods

Experimental location and duration: The experiment was conducted at Sheep, Goat and Horse Farm, Department of Animal Science, Bangladesh Agricultural University, Mymensingh. The compositing period was 30 days.

Design of experiment: The experiments were conducted in aerobic condition with different level of Mg and P salts in layer litter. To fulfill the objectives four treatments were conducted e.g. aerobic composting with layer litter (T_0 = Control), layer litter with 10% $MgCl_2$:KH_2PO_4 (T_1), layer litter with 20% $MgCl_2$:KH_2PO_4 (T_2), and layer litter with 30% $MgCl_2$:KH_2PO_4 (T_3) above soil surface to develop a convenient method of composting. The sample from composted materials was collected at 0, 10, 20 and 30 days for proximate analysis. In each treatment there were three replications to minimize the experimental errors.

Collection of raw materials: The layer litter was collected from Poultry Farm, Bangladesh Agricultural University, Mymensingh. Mg and P salt were collected from central laboratory, Bangladesh Agricultural University, Mymensingh. The raw materials were carried into sac at the Animal Science Field Laboratory and stored in air tight condition.

Preparation of compost bag: An empty room of Field Laboratory, Department of Animal Science was selected to set up the treatment, which was clean and free from logged water and nuisance. At the place of experiment, fours pouches (bag) of polythene were prepared in similar size whose diameter was 75 cm and depth 45 cm. These polyethylene bags were set at the corner of the room and side of the wall to prevent leaching and water contamination with compost.

Preparation of mixture for composting: After collection, the sample was mixed properly. Saw dust was mixed for reducing relative humidity up to 60-65% for rapid composting and then mixed sample was divided into four parts, kept in those polyethene bags at the rate of 3 kg in each. $MgCl_2$ and KH_2PO_4 salts were mixed with polyethene bag of T_1, T_2 T_3 in proper amounts as the design of experiment however only T_0 (control) was chemical free.

Collection of sample for chemical analysis: The treatments were monitoring everyday for taking some physical parameters such as temperature, odors, smell, colour, texture etc. Regular monitoring was also needed for ensuring aerobic condition through opening the bags and giving the air flow in each treatment. First sample was collected in 0 day for analyzing. After every 10 days, samples were collected from all composting bags and analyzed for estimation of dry matter, moisture, crude protein, crude fiber, ash, C/N ratio and pH. Analytical procedures were conducted at the laboratory of Animal Science Department.

Composting method: Every treated and untreated sample was divided into 3 equal parts and kept the previously marked location in the Animal Science Field Laboratory, covered with polyethene and kept 30 days for composting. During this composting period it was found average pit temperature was 36^0C which was very much comfortable to production of compost (optimum aerobic composting temperature 34^0C to 42^0C). The process of composting emitted very litter odor and the samples were taken at 0, 10, 20 and 30 days for chemical analysis.

Chemical analysis of the composting parameters: Representatives samples of different treatment were analyzed in the laboratory of Animal Science Department for the determination of dry matter (DM), Moisture, Crude protein (CP), Crude fiber (CF), ash percent according to AOAC (1990).

Analysis of data: The data were analyzed for in a Completely Randomized Design (CRD) (SAS computer package). Significant mean values were tested with DMRT (Duncan's Multiple Range Test).

Results and Discussion

Effect of Mg and P salts on layer litter composting at 0 day: DM, Moisture and Ash content were varied non-significantly ($P<0.01$) among different treatment groups (Table 1). Significantly ($P<0.05$) highest CP and CF content was observed in T_3 and T_1, respectively at 0 days of layer litter composting. However, C/N ratio was significantly ($P<0.05$) higher in T_0 and the lowest in T_3. p^H values were non-significant differ in $T_{1,}$ T_2 and T_3 at 0 days of layer litter composting.

Table 1. Effect of Mg and P salts on layer litter composting at 0 day

Variance	Treatment				Level of Significance
	T_0	T_1	T_2	T_3	
DM%	44.34±0.3	45.37±0.7	45.40±1.8	47.23±1.91	NS
Moisture%	55.69±0.6	54.73±.93	54.6±1.8	52.86±1.95	NS
CP%	4.25^d±0.08	5.17^c±0.37	7.387^b±0.3	9.66^a±0.23	*
CF%	18.12^c±0.55	22.01^a±0.27	21.19^{ab}±0.14	20.15^b±0.23	*
Ash%	2.73±1.19	2.03±1.1	2.38±1.16	2.59±1.11	NS
C/N Ratio	16.86^a±0.33	12.08^b±.13	10.17^c±0.27	7.12^d±0.08	*
pH	8.07±0.08	7.97±0.14	7.61±0.19	7.57±0.32	NS

Mean values superscript with similar alphabet row and column do not differ significantly ($p<0.01$). T_0 = control T_1= layer litter with $MgCl_2$:KH_2PO_4 (10%), T_2 = layer litter with $MgCl_2$:KH_2PO_4 (20%), T_3= layer litter with $MgCl_2$:KH_2PO_4 (30%)

Table 2. Effect of Mg and P on layer litter composting at 10 days

Variance	Treatment				Level of Significance
	T_0	T_1	T_2	T_3	
DM%	49.98^b±0.69	50.94^{ab}±1.12	51.54^{ab}±2.50	55.91^a±1.22	*
Moisture%	51.35^a ±1.19	49.09^a ±1.13	44.08^b ±1.22	44.08^b ±1.22	*
CP%	2.84^c ±0.18	4.35^b ±0.14	4.51^b ±0.04	6.349^a ±0.41	*
CF%	14.10^c ±0.52	19.28^a ±0.46	16.60^b ±0.26	15.21^{bc} ±054	*
Ash%	2.96^b ±0.89	3.22^{ab} ±0.59	3.36^{ab} ±0.77	3.53^a ±0.87	*
C/N Ratio	34.94^a ±0.38	25.07^b ±0.45	22.17^c ±0.41	18.54^b ±0.86	*
pH	8.48^a ±0.14	7.92^{ab} ±0.38	7.99^{ab} ±0.07	7.17^b ±0.57	*

Mean values superscript with similar alphabet row and column do not differ significantly ($p<0.01$). T_0 = control T_1= layer litter with $MgCl_2$:KH_2PO_4 (10%), T_2 = layer litter with $MgCl_2$:KH_2PO_4 (20%), T_3= layer litter with $MgCl_2$:KH_2PO_4 (30%).

Effect of Mg and P salts on layer litter composting at 10 days: DM content differ significantly ($P<0.01$) among different treatment groups of layer litter composting (Table 2) and the highest DM content was observed in T_3 than other treatments. Adeleye and Kitts (1983) and Muller (1982) reported that dry matter content decreased during composting period. The composting processes in the present study was done during winter season above soil surface decreased the moisture content and increase the dry matter percent of the composting materials. The CP contents were significantly ($P>0.05$) higher in T_3 than that of other treatments. The results are consistent with Taufik *et al.* (1997) and Xian-yuan *et al.* (2010). Significantly ($P<0.01$) highest CF and ash content observed in T_3 from other treatments. However, C/N ratio and P^H were significantly ($P<0.05$) higher in T_0 than other treatments.

Effect of Mg and P salts on layer litter composting at 20 days: The value of DM, moisture and ash content were non-significant at 20 days (Table 3). However, CP content was significantly ($P>0.05$) highest in T_3 than other treatments. The results are agreement of Taufik *et al.* (1997) and Xian-yuan *et al*. (2010) but contradict with Abdelmawa *et al.* (1988) when composted by staking. Significantly ($P<0.05$) higher CF content was obtained in T_2 than other treatments. On the other hand, C/N ratio was significantly ($P<0.01$) higher in T_0 than other treatments however P^H values were higher in T_0 and T_1 than T_4 and T_5. The highest pH was observed in T_0.

Effect of Mg and P on layer litter composting at 30 days: DM, moisture, CF and ash contents were non-significantly differ at 30 days with layer litter composting. However, significantly ($P<0.05$) higher CP content was observed in T_3 than other treatments. The results are contradict with Taufik *et al.* (1997) and Xian-yuan *et al*. (2010) but consistent with Abdelmawa *et al.* (1988) when composted by staking. The C/N ratio was significantly ($P<0.05$) higher in T_0 than other treatments group. However, the P^H differs significantly ($P<0.05$) in all treatment groups. pH was the highest in T_0 and the lowest in T_3.

Table 3. Effect of Mg and P on layer litter composting at 20 days

Variance	Treatment				Level of Significance
	T_0	T_1	T_2	T_3	
DM%	49.30±0.22	49.69±1.89	51.04±0.84	52.56±3.37	NS
Moisture%	50.70±0.23	50.00±1.84	48.95±0.84	47.43±3.37	NS
CP%	4.69^{c} ±0.22	6.61^{b} ± 0.17	9.59^{a} ±0.10	9.64^{a} ±0.43	*
CF%	13.90^{c} ±0.20	19.28^{a} ±0.46	16.50^{b} ±0.23	15.03^{c} ±0.54	*
Ash%	3.40±0.97	3.50±0.53	3.58±0.87	2.94±0.06	NS
C/N Ratio	23.05^{a} ±0.50	16.10^{b} ±0.55	11.02^{c} ±0.06	9.99^{c} ±0.24	*
pH	8.48^{a} ±0.18	8.03^{ab} ±0.10	7.66^{ab} ±0.29	7.10^{b}±0.44	*

Mean values superscript with similar alphabet row and column do not differ significantly ($p<0.01$). T_0 = control T_1= layer litter with $MgCl_2:KH_2PO_4$ (10%), T_2 = layer litter with $MgCl_2:KH_2PO_4$ (20%), T_3= layer litter with $MgCl_2:KH_2PO_4$ (30%)

Table 4. Effect of Mg and P on layer litter composting at 30 day

Variance	Treatment				Level of Significance
	T_0	T_1	T_2	T_3	
DM%	56.03±1.99	55.83±2.22	55.79±0.66	56.04±0.75	NS
Moisture%	41.78±1.01	39.48±2.54	42.43±1.25	43.95±0.75	NS
CP%	5.41^{d} ±0.12	7.45^{c} ±0.33	9.73^{b} ±0.24	12.41^{a} ±0.19	*
CF%	11.96±0.39	14.62±1.10	13.31±1.15	12.03±0.29	NS
Ash%	3.39±0.46	3.46±0.50	3.80±0.74	3.62±0.33	NS
C/N Ratio	21.77^{a}±0.216	16.22^{b}±0.15	12.45^{c} ±0.18	10.11^{d} ±0.00	*
pH	7.90^{a} ±0.10	7.91^{a} ±0.11	7.13^{b} ±0.14	6.92^{b} ±0.19	*

Mean values superscript with similar alphabet row and column do not differ significantly ($p<0.01$). T_0 = control T_1= layer litter with $MgCl_2:KH_2PO_4$ (10%), T_2 = layer litter with $MgCl_2:KH_2PO_4$ (20%), T_3= layer litter with $MgCl_2:KH_2PO_4$ (30%)

Therefore, the use Mg and PO_4 salts improve quality of layer litter compost. From the result it may be concluded that proximate compositions of all samples were acceptable up to the end of composting period. So, addition of 30% Mg and PO4 salts in layer litter composting, N retention as CP, P^H and C/N ratio at the end of the composting period was in optimum condition. Therefore, addition of Mg and PO_4 salts are good to produce high-quality compost containing slowly realizing struvite. So, it is recommended that farmers can practice layer litter struvite composting using Mg and PO_4 salts as organic fertilizer in vegetables field, nursery, tea garden and homestead gardens to improve the soil quality for successful crop production without degradation of environment.

References

Abdelmawla, S.M, Fontenot, J.P. and El-Ashry, M.A. 1988. Composited, deep stacked and ensiled broiler litter in sheep diets: Chemical composition and nutritive value study. VPI & SU Anim. Sci. Res. Rep. 7: 127.

Adeleye, I.O.A. and Kitts, W. D.1983. Poultry wastes as feed for ruminants II. Effect of age of chemical composition of broiler litter and caged layer droppings.Tropical Anim. Prod.8: 15-18.

AOAC, 1990. Official methods of Analysis, 15 th edition. Association of Official Analytical Chemists, Washington, D. C.

Bhattacharya, A.N. and Taylor, J.C. 1975.b Recycling animal waste as a feedstuff: A review. J. Anim. Sci. 41. 1438-1457.

Bhuiyan, M.I., Mavinic, D.S. and Koch, F.A. 2008. Phosphorus recovery from wastewater through struvite formation in fluidized bed reactors: a sustainable approach. Water Sci Technol. 57(2):175-81.

Chirmuley, D.G. 1994. Struvite precipitation in WWTPs: causes and solutions, Water. J. Austr.Water Assoc. December.1994. 21-23.

Jeong, Y. K. and J.S. Kim. 2001. A new method for conservation of nitrogen in aerobic composting process, Bioresour. Technol. 79: 129–133.

Muller, Z.O. 1982. Feed from animal wastes. Feeding manual. FAO Animal Production and Health. Paper No. 28, Rome, cited from Asian Australian J. Anim. Sci. 5(4): 595.

Taiganides, E.P. 1977. Animal wastes.Applied Science Publishers.London. PS001.

Taufik, D.E., Said, G. and Maarif, M.S. 1997 .Study of Preparation of Organic Fertilizer through the Composting of Domestic Wastes Using Liquid Mud of Oxidation Pond. Technology Industry Pertanian, No. 2(1): In: Organic Recycling in Asia and the Pacific, RAP Bull. Reg. Office for the Asia and the Pacific, Food and Agril. Org., Bangkok, Thailand. 13:67.

Xian-yuan1, D.U., Jian-lin1, L.I.U., HUANG Guo-he and Yu, L. I. 2010. Formation of Struvite Crystals in a Simulated Food Waste Aerobic Composting Process. Chem. Res. Chinese Universities 26(2), 210—216.