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Effect of Litter Amendments on Nutrient Quality and Emission of Greenhouse Gas from Poultry Litter During Composting Under Natural Conditions

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ABSTRACT

A study was conducted to estimate the effect of poultry litter amended with sodium bisulphate and alumsulphateon nutrient composition of poultry litter before and after composting. Three experiments were conducted in different seasons (summer, rainy & winter) of the year. Earlier 240 day old commercial broiler chicks were reared under similar environment conditions and their litter was collected after 42 days and was composted under natural conditions. The experiment includes control group (Tc) having no litter amendments whereas treatment groups include litter amendment with sodium bisulphate @ 25 gm/sq.ft. (Ts) and litter amendment with alum sulphate @ 90 gm/sq.ft. (TL). The whole litter comprising treated rice husk, droppings, feed remnants etc. collected from each group was tested for nutritive value before and after composting and release of nitrous oxide (N_2O) gas during the composting period. The nitrogen (N), Phosphorus (P) and Potassium (K) content of the compost was estimated at 0, 30, 60 and 90 days of the composting period. The gas samples were collected on day 0, 20, 40, 60 and 90 days during the composting period. The data revealed that at zero and 30th day of composting period there was a significant ($p \leq 0.05$) higher values of nitrogen in Ts and T_L groups as compared to control group. The phosphorus and potassium content in different treatment groups was non-significant at different intervals of composting. The nitrous oxide emission was also more from the treatment groups as compared to control group.

HIGHLIGHTS

- Poultry litter have high values of nitrogen, phosphorus and potassium.
- Poultry litter also produces greenhouse gas *i.e.,* nitrous oxide during composting.

Keywords: Alum sulphate, broiler, composting, litter, sodium bisulphate

Total poultry population of country is 851.81 million (Livestock census, 2019) which is 16.8% more than the previous census. There is an increase demand for poultry meat and eggs due to its acceptance by most of the society. As the country's poultry population is expanding day by day, farmers are facing problems of disposing large quantities of poultry litter. Improper management and utilization of manure can contribute to environmental degradation and ultimately be detrimental to human and animal health. By agricultural point of view, poultry wastes generated by intensive production play a major role in ground water contamination through nitrate nitrogen. At present most of the people are moving towards organic farming rather than using chemical fertilizers due to their high rising costs (Oyedeji *et al*., 2014). Due to its high content of plant nutrient, poultry litter is considered the most valuable organic resource for fertilizing purpose. Recycling of organic wastes in agriculture adds much

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needed nutrients to the soil (Khan *et al*., 2003). Poultry litter can be applied directly to land but fresh poultry litter may have imbalanced amount of plant nutrients, pathogens and nuisance odors. Proper recycling of organic waste is the need of hour and the best way of recycling the organic waste is composting.

Composting is the decomposition of organic matter under controlled conditions that yield temperatures conducive to thermophilic microorganisms, resulting in a humus like organic material. This process consumes oxygen and releases water, heat and carbon dioxide. Properly composted material is environmentally safe and a valuable soil amendment for growing certain crops as it provides nutrients like nitrogen (N), Phosphorus (P) and Potassium for growth of plant. Composted organic material is not only a source of macro and micro nutrients but they also improve the soil characteristics like water holding capacity, aeration, bulk density etc. Although composting is a natural biochemical decomposition process, a successful composting operation that produces a valuable end product is normally associated with releasing gaseous emissions including greenhouse gases (GHGs) into the atmosphere. The two main green house gases emitted during composting are methane and nitrous oxide. These gases have a direct impact on the global warming, climate change, acidification, and eutrophication of ecosystems (Damodharan *et al.,* 2019).

Farmer's are not handling the poultry litter properly. They generally stockpiled the poultry litter in the open air and as a result there is loss of nutrients and leaching of nitrate into the soil leading to water contamination. In this study, at the end of each experimental trial (summer, rainy and winter), the whole litter comprising treated rice husk, droppings, feed remnants etc. were collected from each pen and was placed individually in different piles. In this study, the composting of litter was done for a period of 90 days and only the moisture content and aeration was maintained.

MATERIALS AND METHODS

Composting is the decomposition of organic matter under controlled conditions that yield temperature conducive to thermophilic microorganisms, resulting in a humus like organic material. Generally it occurs in an aerobic environment. This process consumes oxygen and releases heat, water and carbon dioxide.

At the end of each experimental trial (summer, rainy and winter), the whole litter comprising treated rice husk, droppings, feed remnants etc. were collected from each pen and was placed individually in different piles. In this study, the composting of litter was done for a period of 90 days and only the moisture content and aeration was maintained. A moisture content of about 45-50% was maintained and the compost mass is turned twice a week throughout the compost period. Rest compost mass was remained the same as it was taken away from different treatment groups.

Nutrient quality before and after composting (N, P, K)

The nitrogen (N), Phosphorus (P) and Potassium (K) content of the compost was estimated at 0, 30, 60 and 90 days of the composting period.

Nitrogen

The method used for determination of nitrogen was Micro-Kjeldahl. A small quantity of finely ground material (0.5 g) was weighed and transferred into KEL PLUS automatic extraction flask. The samples were digested with 10 ml conc. H_2SO_4 in presence of 5 g digestion mixture ($CuSO_4$: K_2SO_4 = 1:9) till appearance of light blue colour. After completion of the digestion, the flask was cooled and then transferred into steam distillation chamber. Then 20 ml of 40% NaOH solution was added slowly into distillation flask and ammonia was trapped in 25 ml of 4% boric acid solution with mixed indicator (10 ml/litre) in a conical

Table 1: Research methodology of experiment

Details	Tc	Ts	T_L
Number of birds	60	60	60
Strategy under test	No litter amendment	Litter amendment with sodium bisulphate @ 25 gm/sq.ft	Litter amendment with alum sulphate@ 90gm/sq.ft

flask. The ammonia borate was titrated later with 0.1 N H_2SO_4. The crude protein percentage of the sample was calculated as follows:

$$N\% = \frac{\left(\text{ml } H_2SO_4 \text{ for sample} - \text{ml } H_2SO_4 \text{ for blank}\right) \times \text{Strength} \times 0.014}{\text{Wt. of the sample}} \times 100$$

Phosphorus and Potassium estimation in compost

For determining P and K concentration, compost samples (0.5 g each) were digested in diacid mixture of HNO_3 and $HClO_4$ in the ratio of 4:1 respectively. The digested material was made to 50 ml volume using distilled water. The phosphorus content in compost was estimated by using Vando-Molybdate-Phosphoric acid yellow colour method in nitric acid system (Jackson, 1967). The K content in compost sample was estimated with the help of Lange's Flame Photometer.

Nitrous oxide emission

Compost nitrous oxide emission was measured by deploying closed type chambers made of polymethacrylate with 10 cm internal radius and 20 cm height (Fig. 1). The chambers were equipped with a battery operated fan for mixing the air in head space, a vent tube for pressure equilibration and a rubber septum for collection of gas samples. The chamber was inserted about 1.5cm inside the compost mass and air sample were collected with the help of a 50 ml syringe fitted with a stop cork at 0, 10, 20 and 30 minutes from every treatment group. The gas samples were collected on day 0, 20, 40, 60 and 90 days during the composting period. The collected samples were taken to the laboratory and N_2O concentration was determined by using gas chromatograph (model 2100 Shimadzu Inc, Kyoto Japan). The N_2O concentration was determined by an electron capture detector (ECD). For determination of N_2O, the injection port temperature was 330°C and the column temperature was programmed from 50 to 180°C.

Fig. 1: Nitrous oxide sampling

STATISTICAL ANALYSIS

The data recorded on various parameters was analyzed for statistical differences by the analysis of variance (Snedecor and Cochran, 1980). The treatment means were compared by using the Duncan's multiple range test (Duncan, 1995).

RESULTS AND DISCUSSION

The whole litter comprising treated rice husk, droppings, feed remnants etc. collected from each pen was collected at the end of trial and was tested for nutritive value before and after composting and release of nitrous oxide (N_2O) was measured during the composting period.

The data for the nutritive value of composting for different treatments in different seasons is presented in Table 2, 3 and 4. The data revealed that at zero, 30, 60 and 90 day of composting period there was a significant ($p \leq 0.05$) higher values of nitrogen in T_L and Ts groups as compared to control group. The phosphorus and potassium content in different treatment groups was non-significant during different intervals of composting. A decreasing trends in nitrogen concentration was observed with maximum decrease occurs between 30-60 days of composting period. This decrease might be due to the excessive emission of nitrous oxide and ammonia gas from the compost mass. The phosphorus and potassium content was slightly increasing during the composting period. The findings of the present study is in agreement with the findings of Kenner *et al.* (2014) who reported that about 12-15 % loss

Table 2: Nutritive value of Poultry manure (%) during summer season

Days of composting	Nutrients	Treatments		
		Tc	Ts	T_L
0 days of compost	Nitrogen (N)	$3.36^b \pm 0.04$	$3.62^a \pm 0.16$	$3.91^a \pm 0.01$
	Phosphorus (P)	1.04±0.14	1.08±0.21	1.07±0.01
	Potassium (K)	0.76±0.12	0.81±0.06	0.72±0.03
30 days of compost	Nitrogen (N)	$3.06^b \pm 0.24$	$3.18^a \pm 0.31$	$3.23^a \pm 0.03$
	Phosphorus (P)	1.15±0.27	1.17±0.37	1.28±0.02
	Potassium (K)	0.80±0.06	0.83±0.04	0.88±0.03
60 days of compost	Nitrogen (N)	$2.78^b \pm 0.27$	$2.80^b \pm 0.33$	$3.12^a \pm 0.03$
	Phosphorus (P)	1.31±0.19	1.34±0.27	1.35±0.02
	Potassium (K)	0.94±0.12	0.98±0.08	0.97±0.03
90 days of compost	Nitrogen (N)	$2.47^b \pm 0.12$	$2.61^b \pm 0.14$	$2.91^a \pm 0.03$
	Phosphorus (P)	1.43±0.24	1.47±0.10	1.42±0.02
	Potassium (K)	0.97±0.08	1.06±0.26	0.99±0.03

Table 3: Nutritive value of Poultry manure (%) during rainy season

Days of composting	Nutrients	Treatments		
		Tc	Ts	T_L
0 days of compost	Nitrogen (N)	3.68^b**±0.14**	3.96^a**±0.27**	$4.39^a \pm 0.04$
	Phosphorus (P)	1.06±0.11	1.14±0.16	1.04±0.01
	Potassium (K)	0.78±0.10	0.83±0.11	0.69±0.03
30 days of compost	Nitrogen (N)	$3.26^b \pm 0.06$	$3.53^a \pm 0.18$	$4.15^a \pm 0.03$
	Phosphorus (P)	1.17±0.18	1.20±0.23	1.31±0.02
	Potassium (K)	0.82±0.06	0.87±0.04	0.90±0.03
60 days of compost	Nitrogen (N)	$2.96^b \pm 0.23$	$2.98^b \pm 0.17$	$3.70^a \pm 0.02$
	Phosphorus (P)	1.34±0.13	1.37±0.07	1.40±0.02
	Potassium (K)	0.98±0.06	0.98±0.04	1.02±0.04
90 days of compost	Nitrogen (N)	$2.51^b \pm 0.16$	$2.64^b \pm 0.11$	$3.43^a \pm 0.042$
	Phosphorus (P)	1.46±0.18	1.40±0.08	1.50±0.04
	Potassium (K)	0.99±0.06	1.02±0.13	1.06±0.04

Table 4: Nutritive value of Poultry manure (%) during winter season

Days of composting	Nutrients	Treatments		
		Tc	Ts	T_L
0 days of compost	Nitrogen (N)	4.36^b**±0.12**	4.52^a**±0.12**	4.57^a**±0.05**
	Phosphorus (P)	1.08±0.13	1.13±0.08	1.00±0.01
	Potassium (K)	0.78±0.08	0.83±0.10	0.65±0.03
30 days of compost	Nitrogen (N)	4.74±0.12	4.89±0.15	4.75±0.04
	Phosphorus (P)	1.19±0.16	1.24±0.31	1.35±0.01
	Potassium (K)	0.84±0.04	0.89±0.05	0.91±0.04
60 days of compost	Nitrogen (N)	3.12^b±0.06	3.16^b±0.17	3.41^a ±0.04
	Phosphorus (P)	1.37±0.11	1.41±0.09	1.46±0.03
	Potassium (K)	1.02±0.04	1.04±0.06	1.09±0.04
90 days of compost	Nitrogen (N)	2.68^b±0.13	2.77^b±0.17	3.54 ^{a} ±0.03
	Phosphorus (P)	1.49±0.16	1.53±0.06	1.57±0.05
	Potassium (K)	1.12±0.03	1.14±0.17	1.13±0.05

of total nitrogen occurs during the composting period. An increase in the phosphorus concentration was also found in vermin-composting of poultry litter (Ghosh *et al.,* 2004). Results in the current study are also similar to the findings of Cooperband *et al.* (2002) who found higher P values in the poultry litter after composting process as compared to its mixtures with other wastes.

Table 5: Nitrous oxide emission (µg/m^2/hr) from compost mass of different treatments at different time interval during summer season

Time	Tc	Ts	T_L
0 day	239.43±9.17	247.35±6.15	238.30± 6.40
20 day	214.15^b±12.16	272.23^a±9.07	283.82^a± 5.81
40 day	256.42^b±7.21	306.43^a±11.29	313.73^a± 9.46
60 day	214.72^b±4.19	219.43^b±6.29	277.95^a± 4.72
90 day	104.28±6.17	106.17±5.21	116.37± 9.94

Table 6: Nitrous oxide emission (µg/m^2/hr) from compost mass of different treatments at different time interval during rainy season

Time	Tc	Ts	T_L
0 day	246.8±11.13	268.5±8.13	241.73±12.30
20 day	258.63^b±9.16	299.43^a±11.07	283.09^a±7.10
40 day	268.13^b±8.14	317.23^a±10.31	328.33^a±12.27
60 day	237.5^b±9.31	243.7^a±8.25	252.64^a±7.72
90 day	114.2±6.07	120.3±5.11	129.93±7.94

Table 7: Nitrous oxide emission (µg/m^2/hr) from compost mass of different treatments at different time interval during winter season

Time	Tc	Ts	T_L
0 day	244.4±13.16	266.5±6.15	237.1±17.24
20 day	268.12^b±5.14	309.30^a±4.22	297.40^a±2.10
40 day	289.41^b±14.24	397.90^a±5.41	342.42^a±7.27
60 day	220.7±14.18	253.9±6.27	226.9±13.08
90 day	106.10±9.08	126.70±5.09	120.61±5.16

The data for nitrous oxide emission from different treatment group during different season is presented in Table 5, 6 & 7. The data revealed that nitrous oxide emission from T_L and T_s group was more than control groups during the whole compost period. There was a significant (p 0.05) higher emission of nitrous oxide gas at day 20 and 40 of compost period in the T_L and T_s group as compared to control. After 60 days, the nitrous oxide gas emission declines in all the groups. The data for nitrous oxide gas emission shows that during initial thermophilic phase of composting the emission is less but as the thermophilic phase is over, the emission of nitrous oxide gas from the composted mass start increasing. This emission was maximum at 40 days of composting period. These findings are in agreement with the findings of Petersen *et al.* (1998) and Sommer (2001) who reported that nitrous oxide emission was low during the initial phase of composting.

CONCLUSION

Addition of litter amendments had a significant ($p \leq 0.05$) effect on nitrogen content of the compost mass. The phosphorus and potassium levels although non-significant but was more in the treatment group as compared to control group. There was a significant ($p \leq 0.05$) higher emission of nitrous oxide gas at day 20 and 40 of compost period in the T_L and T_s group as compared to control. After 60 days, the nitrous oxide gas emission declines in all the groups.

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