Original Research Article

Repercussion of controlled decomposition process on carbon dynamics and quality evaluation in chicken manure pellets

Abstract

An incubation experiment was conducted to determine the decomposition potential of the chicken manure pellets and to know the nutrient composition. The chicken manure pellets produced from the bedding material of commercially grown broiler farm was tested for decomposition rate through CO_2 evolution and nutrient content. The rate of decomposition of poultry manure pellets (CO_2 emission) was less during the first week of incubation and linearly enhanced during 2nd and 3rd week after incubation. The rate of emission of CO_2 has been reached maximum (150 mg of CO_2 per gram per day during the 4th week of incubation. The enhanced CO_2 evolution indicated addition of more organic matter content and balanced steady release of nutrients on incorporation in to soil.

Keywords: Chicken manure, Plant nutrients, Carbon emission, Crop growth.

Introduction

A fertilizer plays an important role in crop growth and development by providing plants essential nutrients (Yadav et al., 2024). Inorganic fertilizer usage has been increased drastically due to its significant role in increasing crop production. The continuous use of chemical fertilizer leads to deteriorating soil health, environment including potential risk of pollution of air, water and soil (Srivastav et al., 2024; Rashmi et al., 2020). However, synthetic fertilizers are replaced by organic fertilizers to create sustainable practices in agricultural production (Wang et al., 2024) especially in organic farming. The broiler poultry farming industry in India has seen impressive growth in recent years and estimated that about 5 million tonne of broiler meat is produced annually. The average daily fresh manure production by broiler chicken is about 43 kg per 1000 kg live weight. Poultry manure is high in organic materials and contains nutrients essential for crop production. One of the readily available sources of organic amendment is chicken manure. Chicken manure used as organic fertilizers for increasing soil fertility and to enhance yields of agricultural crops Ravindran et al., 2017). Chicken manure able to enhance the soil fertility compared to synthetic fertilizer which includes enhanced soil structure, superior nutrient availability status and increasing soil biotic organisms leads to better crop yields (Essilfie et al., 2024; Chen et al., 2022). Application of chicken manure increased available nitrogen and increased Cation exchange capacity significantly (Adekiya et al., 2020).The utilization rate of this manure is forty per cent lesser in agricultural production (Ning et al., 2022). Chicken manure had a role on sequestrating the soil organic carbon (SOC). The slight changes in soil organic carbon (SOC) had significant effect on global climate change (Das et al., 2024). With this background, the study was conducted to evaluate the dynamics of carbon dioxide emission under controlled environment and changes in soil nutrient status on addition of chicken manure pellets.

Highlights

Exploited the use of bedding material of commercially grown broiler poultry farm for sustainable Agriculture.

Chicken manure pellet was rich in essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K), which is crucial for plant growth and development

Rate of emission of CO_2 has reached maximum (150 mg of CO_2 per gram per day) during the 4th week of incubation showing the complete decomposition of chicken manure pellets

Pellet form of chicken waste helps in minimizing nutrient leaching and runoff into water bodies so as to reducer environmental pollution (Alves et al., 2023).

Materials and methods

The sample was collected from a broiler poultry farm which is operated in collaboration with SKM Chickens private Ltd., established in 2013. The farm encompasses a total of ten acres of cultivable land located in Nanalkaadu, Tuticorin district. Approximately 2,641 chicks per shed were accommodated for growing. Coir pith is a by-product obtained from the husks of coconuts was used as a bedding material. An automated fogger system was employed to regulate the humidity levels. To ensure uniform heat distribution, incandescent light bulbs were installed. Separate chambers were designated for feed and watering, with an automized water supply system. After a period of 40-days growing of the chickens, the bedding material combined with chicken waste was collected. The collected manure was subjected to a drying process to reduce its moisture content. This drying can be achieved through natural sun shade drying, mechanical drying, or a combination of both methods. For effective palletisation, the target moisture content should be around 15-20%. Subsequently to drying, the manure was pulverized into a finer particulate form using a hammer mill or grinder, which ensures a uniform particle size for the pelletizing process. The powdered material was then fed into a pellet mill. In the pellet mill, the material was extruded through a dia under higher pressure, forming cylindrical type of pellets. The diameter of the pellets is determined by the size of the dia used. The freshly formed pellets were initially hot and soft. They were then subjected to cooling using a pellet cooler, which reduced the temperature of the pellets and protect it from breakage. Additionally, this process of cooling further reduced the moisture content of the pellets. The resultant pellets were then ready to apply in the agricultural field.

Weekly samples were collected from the poultry shed over a period of four weeks. The nutrient content and quality of the collected chicken manure pellet were determined using alkaline permanganate method (Nitrogen), colorimetric method (Phosphorus), flame photometer (Potassium), potentiometric (pH) and conductometric (EC) methods respectively. Further, an incubation study was carried out for 56 days to determine the dynamics of carbon dioxide emission (Figure 1.). The CO_2 evolution was measured using the alkaline absorption method under anaerobic conditions. The experimental setup involved mixing 250 grams of soil sample with 0.5 grams of poultry manure pellets, which was placed in a 500 mL conical flask and maintained under saturated conditions. A 10 mL aliquot of 0.1 N sodium hydroxide (NaOH) solution was introduced into a test tube, which was inclined inside the conical flask using a thread. The conical flask was sealed with non-absorbent cotton and covered with aluminium foil to maintain a controlled environment. Another set of conical flask apparatus was set up with soil alone without mixing poultry pellets (control). To measure the amount of CO_2 absorbed in the 0.1 N NaOH solutions, it was titrated with 1 N hydrochloric acid (HCl) using phenolphthalein as an indicator until the color changed from pink to colourless.

Figure 1. Incubation of treated and non-treated samples in replicates

Results and discussion

Characteristics of experimental soil

The soil used in this experiment was sourced from the fields at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Killikulam, Tuticorin district, Tamil Nadu, India during the non-crop period of April-May, 2024. The soil texture was identified as sandy clay loam with the composition of clay (28%), silt (15%), coarse sand (25%), and fine sand (31%). The physical and chemical properties of the soil were determined, Bulk density 1.22 mg m^{-3}, Water holding capacity (WHC) 55%, pH 7.65, Electrical conductivity (EC) 0.17 ds m^{-1}, Soil organic carbon (SOC) 0.51%, Available nitrogen (N) 210.29 kg ha^{-1}, Available phosphorus (P) 18.42 kg ha^{-1} and Available potassium (K) 196 kg ha^{-1}.

Chacteristics of chicken manure pellet

Chicken manure pellet was collected on weekly basis from June, 2024 to July, 2024 to analyze the effect of duration on improvement in the nutrient status of the pellet. The nutrient contents of the chicken manure pellets are presented in the Table 1. It was observed that the nutrient content of the pellet was significantly increased over time. These variations were attributed due to the fluctuations in the nutrient composition of the feed and the period of bedding waste collections for pelleting. The manure pH was initially acidic in nature and slowly changed into alkaline as the period of advancement of growing due to the deposition of calcium rich poultry droppings. The electrical conductivity (EC) was also enhanced from 0.11 dsm^{-1} during the first week to 0.58 dsm^{-1} during the fourth week. But the nitrogen content varied from 41.3 to 42.56; the phosphorus content ranged from 23.4 to 28.21 and the potassium content from 17.78 to 32.68 percent. The variation in the nutrient content of the chicken manure depends on the age of the birds and the type of feed supplied during the growing of broiler chicken. Nutrient assessment of chicken manure pellet showed that the pellets was rich in essential nutrients (Minkina et al., 2023) such as nitrogen (N), phosphorus (P), and potassium (K), which is crucial for plant growth and development (Gehan et al., 2010). The nutrient composition may vary but generally provides a balanced fertilizer for crops (Harahap et al., 2020). Pellets are denser than raw manure, which makes them easier for handling, transportation, and storage.

Table 1.physic chemical properties and nutrient stauts of weekly collected sample

Sample collection	Nitrogen (%)	Phosphorus (%)	Potassium (%)	pH	Ec (dsm^{-1})
1st week	42.56	23.40	17.78	5.25	0.11
2nd week	42.28	24.45	31.00	7.30	0.18
3rd week	41.80	24.92	31.36	8.10	0.40
4th week	41.30	28.21	32.68	8.70	0.58
Mean	41.99	25.25	28.21	7.34	0.32

CO_2 dynamics

The CO_2 evolution was measured from 1 to 49 days after of Incubation (Fig. 1). The result showed that the rate of decomposition of poultry manure pellets (emission) was less during the first week of incubation and linearly enhanced during 2nd and 3rd week after incubation. The rate of emission of CO_2 has been reached maximum (150 mg of CO_2 per gram per day during the 4th week of incubation (21st to the 42nd day). Then the emission was declined after wards. On comparing the non-treated (T_1) and treated (T_2) sample, it is observed that the chicken manure pellets (T_2) had greater CO_2 evolution than T1 (raw coirpith). An increase in CO_2 evolution indicated an enhancement in the organic matter content within the soil (Nkoh et al., 2024). Due to the compact nature of the chicken manure pellets, it evolved more CO_2 than raw chicken manure and other organic amendments (Elrajhi, 2024). This shows the steady and quick release of nutrients from manure to plants (Steiger et al, 2024). The pellet form of chicken waste helps in minimizing nutrient leaching and runoff into water bodies so as to reducer environmental pollution (Alves et al., 2023).

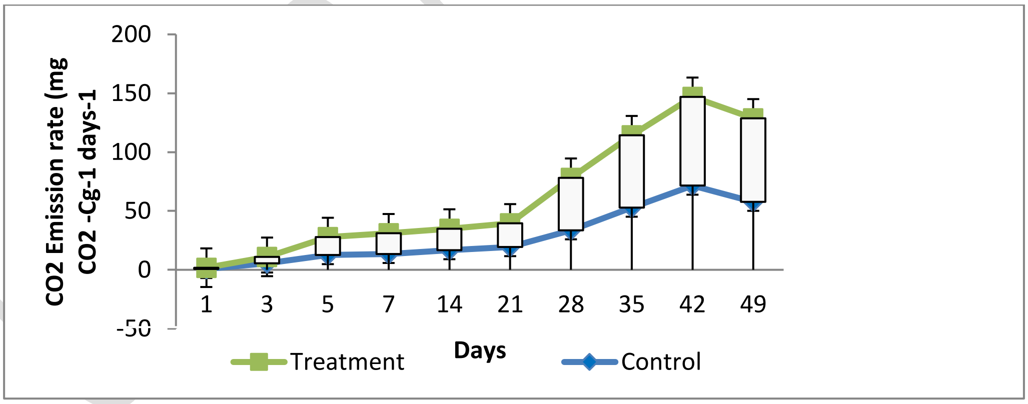

Figure 2. CO_2 evolution of treated and non-treated soil under controlled condition.

Conclusion

Chicken manure pellets exhibited a significant increase in nutrient content over time, indicating to use it as a nutrient-rich organic fertilizer. These pellets were characterized as higher densified and pave way for easy handling. It released more CO_2 than raw manure and releasing consistent and balanced supply of essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K). Consequently, chicken manure pellets represent a robust and environmentally sustainable option for crop fertilization. Future research could focus on optimizing pellet formulation and application methods for further improvement on nutrient use efficiency and environmental impact.

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