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Co-composting of domestic waste and poultry waste along with cattle dung for sustainable organic manure production

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Abstract

Co-composting of organic wastes such as domestic waste and poultry waste is widely recognized as an effective strategy for simultaneously managing these wastes while reducing common composting challenges, such as greenhouse gas emissions and nutrient losses. Although these materials are biodegradable in nature, improper disposal and management can lead to significant environmental concerns. Composting has emerged as an effective and sustainable method for treating organic wastes by converting them into a stable product that can be utilized as a soil conditioner. Owing to its low cost and environmentally friendly nature, composting offers a practical solution for organic waste management. In this study, pit house experiment was conducted at CCS HAU, Hisar to evaluate the co-composting of Domestic waste and poultry waste alongwith with cattle dung. In the present study, organic waste was composted along with leaf litter in a pit house located. Compost samples were collected at 30-day intervals and analyzed for changes in organic carbon, nitrogen (N), phosphorus (P), potassium (K), and C:N ratio. After 90 days of composting, organic carbon content decreased from 44.86% to 32.85% while nitrogen content increased from 0.89% to 1.67%. The C:N ratio declined from 49.88 to 21.31, indicating progressive decomposition and stabilization of the compost. Similarly, phosphorus content increased from 0.45% to 0.79%, and potassium content increased from 1.02% to 1.81%. These findings demonstrate that the conversion of organic wastes such as domestic waste and poultry waste into compost can serve as an effective strategy for recycling nutrients and improving soil fertility, thereby contributing to sustainable soil nutrient management.

Keywords: Agriculture, composting, domestic waste, organic waste, poultry waste

Introduction

Organic waste has emerged as a major global environmental concern due to the vast quantities generated worldwide. Inadequate management practices, such as landfilling and incineration, can lead to various environmental problems. Composting of organic waste such as domestic waste is widely recognized as an effective method for managing and disposing of solid wastes. This process enhances waste management by reducing its volume and weight, eliminating pathogenic microorganisms, and stabilizing nutrients and organic matter present in the waste (Tiquia *et al.* 2000) ^[18]. The utilization of compost in agricultural fields is regarded as a cost-effective, practical, and environmentally sustainable waste management strategy (Brochier *et al.*, 2012) ^[5]. Furthermore, well-managed composting minimizes odour generation and nitrogen losses, transforming organic residues into a stable, nutrient-rich product suitable for use as an organic fertilizer.

Composting reduces the volume of manure and other organic wastes through the biochemical mineralization of organic compounds. The incorporation of compost into soil enhances soil fertility, improves nutrient availability, and reduces the risk of spreading pathogens and weed seeds (Zhang *et al.* 2016) ^[20]. Although composting is widely regarded as an environmentally friendly and versatile waste management technique with broad applicability to various organic materials (Saer *et al.* 2013) ^[17], the process is often accompanied by emissions of ammonia (NH₃) and greenhouse gases (GHGs), including carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). These emissions not only diminish the nutrient content of the final compost

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but also reduce the environmental benefits associated with composting. During the composting process, carbon is primarily lost as CO₂ and CH₄ through the mineralization of organic matter and the reduction of acetic acid and CO₂. Similarly, nitrogen losses occur through NH₃ volatilization and N₂O emissions resulting from nitrification and denitrification processes, leading to nutrient depletion and affecting microbial degradation dynamics.

Poultry manure is a valuable source of essential nutrients and is widely recognized for its ability to enhance crop productivity and improve soil structural stability. For efficient composting and to create favorable conditions for microbial activity, maintaining an appropriate carbon-to-nitrogen (C:N) ratio is crucial. Animal manures, including poultry manure, are generally rich in nitrogen, and their successful composting often requires blending with carbon-rich materials to achieve a balanced C:N ratio (Zmora-Nahum *et al.*, 2007) [22]. Several studies have reported effective composting of animal manures when combined with high-carbon substrates such as sawdust (Zhang and He, 2006) [21] and wood chips (Adhikari *et al.*, 2008) [1]. In addition, lignocellulosic agricultural and forestry residues, including pine shavings and sawdust, are commonly utilized as bulking agents during composting because they improve aeration, moisture balance, and overall compost quality (Bernal *et al.*, 2009) [3].

Adequate oxygen supply is essential for maintaining aerobic microbial activity during composting. However, excessive aeration may cause excessive heat loss, thereby preventing the development of the thermophilic conditions necessary for efficient decomposition. Conversely, insufficient aeration can create anaerobic conditions, which adversely affect the composting process. Therefore, an optimum aeration rate is required to ensure an adequate oxygen supply for aerobic decomposition. The aeration rate influences microbial activity, decomposition efficiency, and temperature dynamics throughout the composting process (Kuter *et al.*, 1985) [12]. Successful composting depends on the proper management of several key factors, including moisture content, carbon-to-nitrogen (C:N) ratio, aeration rate, temperature, pH, composting substrates, and the composting method employed. Previous studies have demonstrated that temperature and moisture content, along with factors such as nutrient balance (C:N ratio), pH, and nutrient availability, play significant roles in determining composting efficiency and the quality of the final compost product (Jackson and Line, 1997) [9]. Keeping in view the above facts, the present study was conducted to explore the utilization of domestic waste and poultry waste along with cattle dung for compost preparation.

Materials and Methods

Composting Substrates

Domestic waste samples were collected from various dumping sites such as Azad Nagar, Chandan Nagar, Hisar and poultry waste samples were collected from Department of Animal Sciences, LUVAS, Hisar.

Preparation of compost pits

Composting of domestic waste and poultry waste along with cattle dung was carried out using following treatments

T₁: Domestic waste alone

T₂: Poultry waste alone

T₃: Domestic waste + Poultry waste (5:1) + cattle dung (10%)

T₄: Domestic waste + Poultry waste (10:1) + cattle dung (10%)

T₅: Domestic waste + Poultry waste (15:1) + cattle dung (10%)

Location: Pit house; Design: CRD; Replications: 2

Cattle dung @ 10% was added as inoculum in all treatments except T₁ and T₂.

Cemented pits measuring 1.5 × 1.5 × 1.5 ft were used for the composting process, with each pit containing 5 kg of composting material. To maintain adequate aeration and promote uniform decomposition, the substrate was turned at regular intervals. Samples were collected from the pits every 30 days and analyzed for various physicochemical parameters throughout the composting period.

Physicochemical analysis of compost samples

During composting process, changes in different physicochemical parameters such as total organic carbon, total nitrogen, available phosphorus and available potassium content were determined using standard protocols. For the estimation of total organic carbon, dry combustion method was used as described by (Nelson and Sommers, 1982) [14]. Kjeldahl's method (Bremner and Mulvaney, 1982) [4] was used for estimation of total nitrogen content. Determination of available phosphorus was done by Olsen's methods (Olsen *et al.*, 1954) [16] and available potassium content was detected by Jackson's methods (Jackson 1965) [10] in compost samples.

Results and Discussion

In the present investigation, Composting of domestic waste and poultry waste along with cattle dung in various combinations was carried out in cemented pits of size 1.5× 1.5 ×1.5 ft.

The total organic carbon content decreased progressively across all treatments during the composting process. After 90 days of composting, organic carbon levels showed a significant reduction, declining from 44.86% to 32.85%. The greatest decrease was observed in Treatment T₂ (Poultry Waste alone), where the organic carbon content reached 32.85% after 90 days of decomposition. This was followed by Treatment T₃ (Domestic Waste + Poultry Waste (5:1) + Cattle Dung (10%)), which recorded an organic carbon content of 35.00% (Fig. 1). The reduction in total organic carbon observed in Treatments T₂ (32.85%) and T₃ (35.00%) is consistent with the findings of Nguyen *et al.* (2020) [15]. Similarly, Hwang *et al.* (2020) [7], while investigating the co-composting of chicken manure with organic wastes, reported a significant decline in total organic carbon content during the final stages of composting. These observations support the results of the present study and indicate the effective decomposition and stabilization of organic matter during the composting process.

Organic carbon (OC) is a vital component required by microorganisms for both energy and cellular growth. During composting, microbes decompose organic matter into simpler substances that can be readily utilized. As they metabolize carbon-rich materials, a significant portion of the organic carbon is consumed as an energy source and released as carbon dioxide through respiration. Since easily degradable carbon compounds are broken down first, the overall organic carbon content gradually decreases as the composting process progresses.

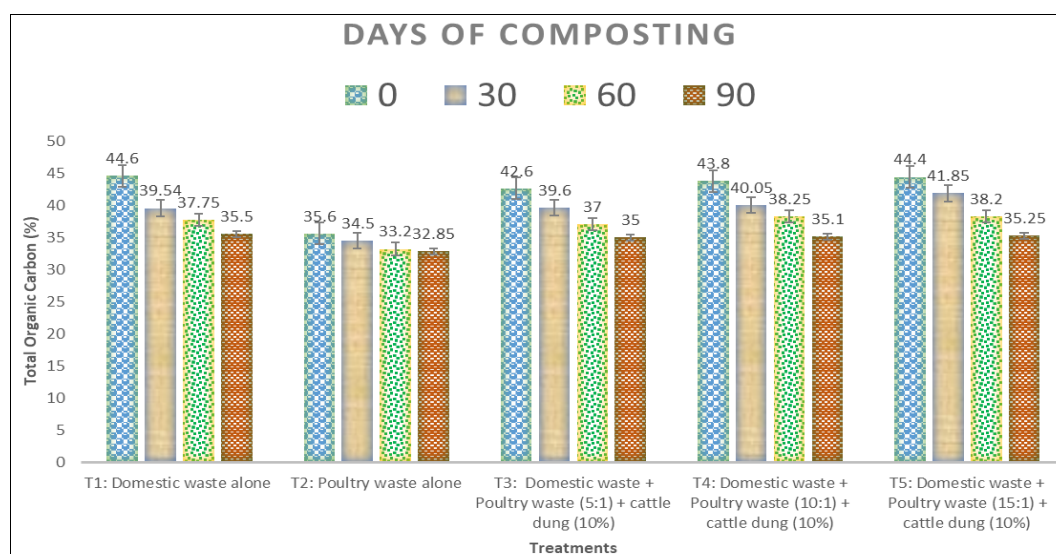


Fig 1: Changes in total organic carbon (%) after 30 days interval

In the present study, the initial value of N was recorded as 0.89% for treatment T₅ (Domestic waste + Poultry waste (15:1) + cattle dung (10%)) which increased significantly during progression of the experiment. However, in treatment T₂ having poultry waste alone, maximum increase in nitrogen content was observed i.e. 1.21% to 1.67% after 90 days of composting (Fig. 2). At the end of composting all treatments showed an increasing trend in total N content. Similarly, Khyalia *et al.* (2021) [11] in their investigation observed that total N content increased significantly with composting time in all the composting treatments prepared from rice straw, green leaves, poultry droppings alongwith fungal inoculant which was found to be

increased from 0.56% to 1.04% after 90 days of Composting. The nitrogen content (%) increases progressively during composting because a substantial portion of the organic carbon is lost as carbon dioxide (CO₂) through microbial respiration, resulting in a reduction in the overall mass of the compost. Simultaneously, moisture loss and the decomposition of organic matter further decrease the total weight of the material. As a result, nitrogen becomes more concentrated in the remaining compost. Additionally, microbial activity contributes to the mineralization of organic nitrogen into more available forms, leading to an apparent increase in nitrogen content during the composting process.

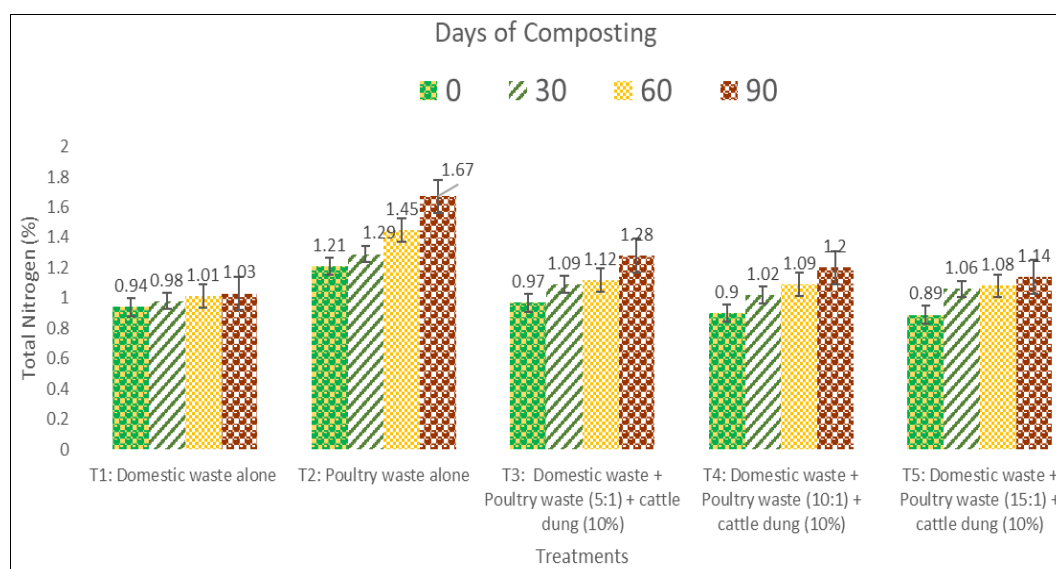


Fig 2: Changes in Total Nitrogen (%) after 30 days interval

As the decomposition progressed, C/N ratio significantly decreased in all treatments. After 90 days of composting, a significant reduction in the C/N ratio was observed from 49.88 to 21.31. The lowest C/N ratio (21.31) was recorded in the

treatment comprising Poultry Waste alone (Fig.3). The reduction in carbon coupled with the gradual increase in nitrogen content resulted in a lower C:N ratio, indicating the stabilization and maturation of the compost.

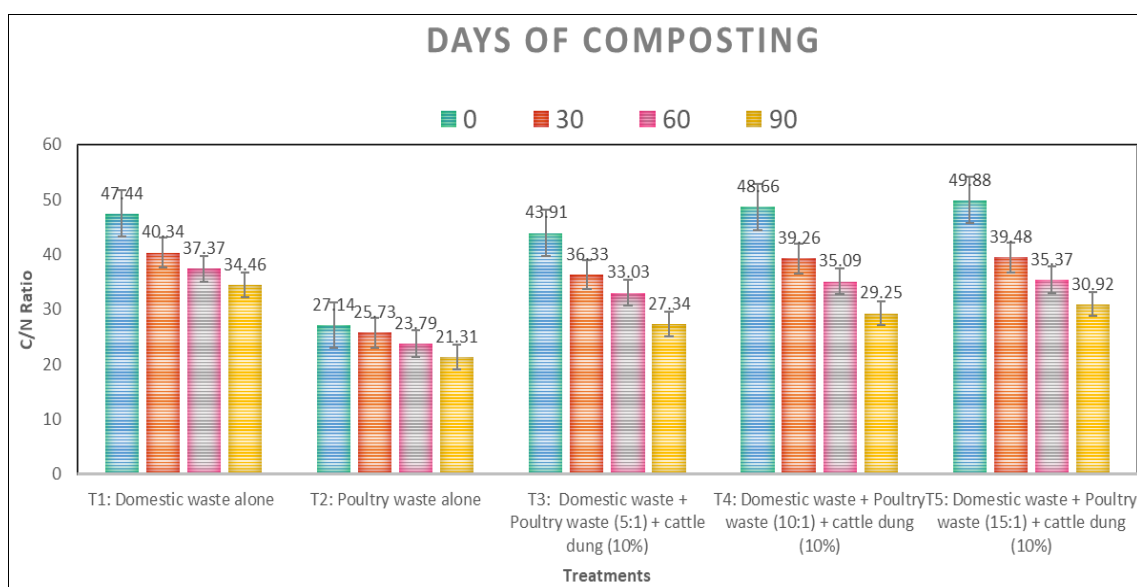


Fig 3: C/N ratio observed after 30 days interval

Indumathi (2017) ^[8] also reported a significant reduction in the C:N ratio across all treatments by the end of the composting process. Similarly, Zaher *et al.* (2009) ^[19] stated that a C:N ratio below 25 indicates satisfactory compost maturity, while a ratio of 20 or less is considered ideal. In accordance with these findings, the C:N ratio of the compost produced in the present study falls within the acceptable range for mature compost.

The initial phosphorus (P) content was recorded as 0.45% in treatment T₁ (Domestic waste alone). As decomposition progressed, a significant increase in P concentration was observed across the composting period, reaching a maximum value of 0.79% in treatment T₂ (Poultry waste alone) after 90 days of composting (Fig. 4).

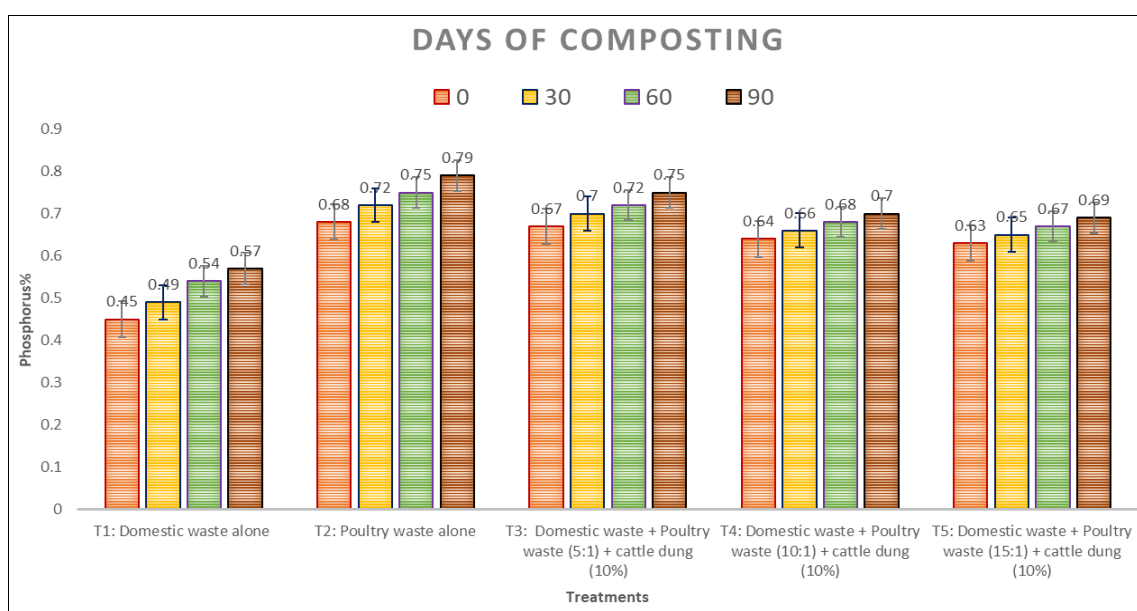


Fig 4: Changes in phosphorus% after 30 days interval

Likewise, potassium (K) content increased from 1.02% at the beginning of the experiment to 1.81% at the end of the composting process. A significant enhancement in K content was noted in all treatments, with the highest value (1.81%) being recorded in treatment T₃ (Domestic waste + Poultry waste (5:1) + cattle dung (10%)) after 90 days (Fig. 5). These findings are in agreement with those reported by Khyalia *et al.* (2022) ^[11] who used rice straw, leaves, poultry waste, and a fungal inoculant for composting and observed a progressive increase in phosphorus

content and potassium content during composting. The phosphorus and potassium contents increased progressively in all treatments during the composting process. This increase can be attributed to the decomposition and mineralization of organic matter by microorganisms, which released phosphorus and potassium from complex organic compounds into more available forms. Consequently, the contents of these nutrients increased as decomposition progressed.

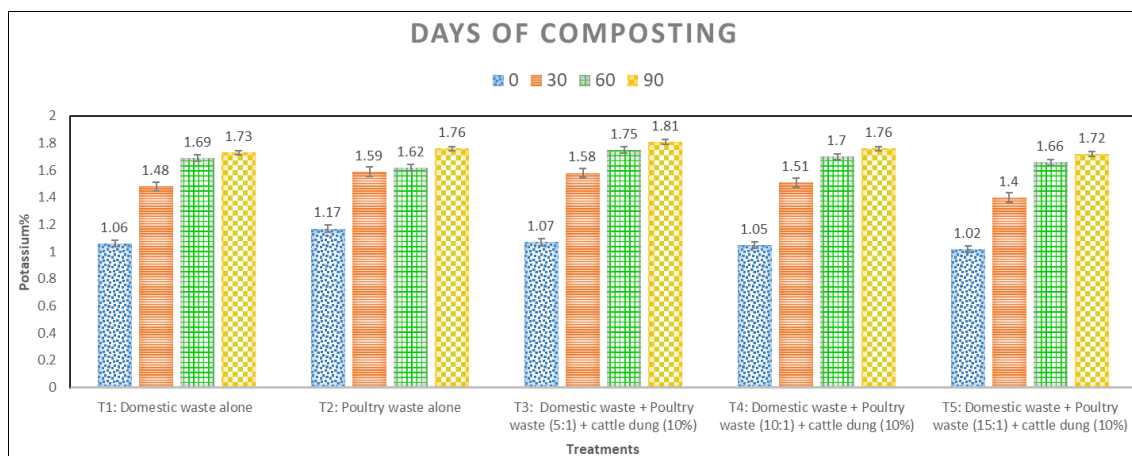


Fig 5: Changes in Potassium% after 30 days interval

Organic carbon and total nitrogen are key parameters governing the microbial decomposition of organic wastes (Meng *et al.*, 2018) [13]. The carbon-to-nitrogen (C:N) ratio is widely recognized as an important indicator of compost maturity and stability. An excessively high C:N ratio may lead to nitrogen limitation, whereas a very low C:N ratio can result in carbon deficiency; both situations adversely affect microbial activity and consequently slow down the composting process. Therefore, maintaining an optimum C:N ratio, generally between 25:1 and 35:1, is essential for producing high-quality compost, as recommended by several researchers (Chung *et al.*, 2021) [6]. In the present study, a significant reduction in the C:N ratio was observed after 90 days of composting, with the lowest value (27.34) recorded in the treatment comprising domestic waste, poultry waste (5:1), and cattle dung (10%). This decline in the C:N ratio indicates enhanced decomposition and compost stabilization. The findings are consistent with those reported by Barapatre *et al.* (2020) [2] also observed a reduction in the C:N ratio during the composting process. Furthermore, a significant difference in the C:N ratio was observed among the treatments and the control after 90 days of composting.

Conclusion

The present study demonstrated that co-composting domestic waste with poultry waste and cattle dung is an effective approach for producing nutrient-rich and stable compost. During the 90-day composting period, a significant reduction in organic carbon content was observed, indicating active microbial decomposition of organic matter. Simultaneously, the total nitrogen content increased significantly which suggests the concentration and mineralization of nutrients during the composting process. A substantial decrease in the C:N ratio was recorded, with the lowest value (27.34) observed in the treatment containing domestic waste, poultry waste (5:1), and cattle dung (10%), indicating enhanced compost maturity and stability. Furthermore, phosphorus and potassium contents increased significantly throughout the composting period. The enrichment of these essential plant nutrients highlights the beneficial role of poultry waste in improving the fertilizer value of the final compost.

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