Dryland Soil Research, Vol. 2, No. 1, pp. 163-170, 2025
Type of article: Original, Available online at www.dlsr.iut.ac.ir.
https://doi.org/10.47176/dlsr.02.01.1058

Effect of carbon-to-nitrogen ratio of chicken manure on composting process with turned-windrow pile method

Vahid Hasanmoghaddam and Amir Hossein Khoshgoftarmanesh†

Department of Soil Science, College of Agriculture, Isfahan University of Technology, Isfahan, Iran

†*Corresponding Author Email: amirhkhosh@iut.ac.ir*

(Received 5 July 2026, Received 24 July 2026, Accepted 13 August 2026)

Abstract

Despite benefits of using chicken manure as an organic amendment to soils deficient in organic metter, there are several conerns on direct application of the manure. The composting is a common process which help to overome the restrictions of using raw manure in agricultural soils, A better knowledge on the optimum conditions for composting is necessary to improve the efficiency of composting and achieveing a proper product. In this study, we investigated the optimum carbon-to-nitrogen ratio of raw chicken manure for composting process. For this purpose, the raw materials with three C:N ratios including 1:20, 1:25, and 1:30 were prepared by combination of chicken manure and various amounts of sawdust. The amounts of sawdust were chosen by considring the target ratio of carbon to nitrogen of the raw materials and the C and N contents of sawdust. The composting materials were sampled from different piles (75-cm depth). Results showed that the composting resulted in significant loss of nitrogn from the chicken manure; about 45% recudtion in nitrogen of compost was found in comparison with the raw chicken manure. The EC of the compost decreased at all C:N treatments over time. In contrast, an increase in pH of composting pile (increased to about 7) was observed at the final step that might be an indictor for compost maturity. In two weeks, a significant reduction in the concentration of NH_4^+ and micrbial activity of compost was observed while after 2 weeks, the NH_4^+ concentration and microbial activity remained unchanged to the end of compositng. In conclusion, a chicken manure with carbon-to-nitrogenn ratio of 30 led to the lowest loss of nitrogen in the form of NH_3 and produced a compost with lower pH containing higher amounts of N and organic matter.

Keywords: Ammonium, Manure, Organic amendment, Soil Fertility, Sustainable agriculture.

1. Introduction

The use of animal manures as a natural soil amendment—particularly to increase soil organic matter—has risen in recent years (Ajwa and Tabatabai, 1994). These manures are rich in nutrients, and their application to agricultural land can enhance soil fertility (Foth and Ellis, 1998). The fertility of the soil depends on the spatial variability of soil properties and nutrients, hence the need for site-specific soil assessment and management (Rezaie *et al.,* 2026). Furthermore, unlike many chemical fertilizers, they persist longer in the soil, sometimes remaining effective for as long as two to three years (Ajwa and Tabatabai, 1994).

However, improper management of this rich organic resource can lead to serious ecological concens, for example elevated loss of nutrients from agricultural fields through leaching, erosion, and runoff (Levi-Minzi *et al.*, 1986).The abundance of simple nitrogenous organic compounds in fresh animal manure is highly problematic. Excessive application of animal manure results in air and groundwater pollution (Levi-Minzi *et al.*, 1986). In addition, the rapid decomposition of fresh manure releases NH_3 gas, which accumulates near the roots and leads to plant toxicity (Mahimairaja *et al.*, 1994). High salt content in the fertilizer can also induce osmotic stress or might be toxic to the plant (Lyimo *et al.*, 1994). Furthermore, the direct application of poultry manure causes environmental issues such as the release of toxic gases, leaching of nitrate, and contamination of water sources. Composting is a common practice to mitigate the problems associated with soil application of poultry manure (Kumar *et al.*, 2010).

Given the growing use of animal manure compost in agriculture in recent years, optimum conditions for composting process is of great improtance to achieve the maximum quality and nutritional value of the compost (Mahimairaja *et al.*, 1994). The efficacy of organic fertilizers could also be affected by the existing conditions of soil fertility, which may vary spatially, thus implying that they need to be applied in the context of site-specific soil management (Rezaie *et al.,* 2026). In addition, there are certain environmental issues arising from improper management or application of this nutrient-rich resource in soil. Therefore, understanding of the composting process and the factors influencing it could be key to resolving issues (Kumar *et al.*, 2010).

The optimal levels of factors influencing the composting process can lead to the production of high-quality compost while simultaneously reducing production costs. Consequently, proper management allows for the utilization of this rich resource while minimizing environmental pollution. Indeed, understanding the physicochemical properties of animal manure during composting is essential for identifying the best production strategies and accurately assessing crop fertilizer requirements (Calderon *et al*., 2005). Thus, any fertilizer and organic amendment suggestions must take into consideration soil nutrients that vary in spatial distribution rather than applying the same rate uniformly (Rezaie *et al.,* 2026).

Furthermore, knowledge regarding the impact of temperature and the C:N ratio on compost quality and maturity is crucial for producing organic materials that meet required standards, thereby fostering sustainable agricultural development (Eghball *et al*., 1997).

The present study was performed in order to investigate how C:N ratio of piles consisted of chicken manure and sawdust infuence the composting process and the chemical properties of the compost.

2. Materials and Methods

The stockpiles of poultry manure stored outdoors at the Zarrin Kesht Sepahan industrial poultry manure processing plant were utilized in collaboration with the Soilless Culture Center at Isfahan University of Technology. Poultry manure piles with varying C/N ratios were formed outdoors, with a height of 1.4 meters. Six piles were used for data collection during the warm season (late summer to early autumn). Sawdust, due to its high carbon content, was used in order to achive the target C to N ratio of the raw materials.

Based on the mass of the poultry manure piles (16 t each) and carbon-to-nitrogen ratio of the sawdust (400:1), quantities of 463, 682, and 908 kg of sawdust were mixed with the respective manure piles to adjust the C:N ratios to 20:1, 25:1, and 30:1. The aeration was performed based on the temperature of the compost pile. By turning the compost pile, the temperature in the core (at a depth of 75 cm from the surface) was maintained below 65°C (Eghball *et al*., 1997). To aerate the compost piles, a tractor-based windrow-turning method was employed. The water content of the compost pile at the beginning was adjusted to approximately 65% (by weight) through irrigation with tap water (Haga, 1999). The stabilization of the compost pile temperature over seven consecutive days was used to identify the maturity of compost and successful ending of the composting process.

Sampling

Sampling was conducted at depths of 5, 75, and 130 cm from the top layer of the compost pile. Specifically, multiple samples were taken from various locations at each depth within a given pile and pooled; a total of three replicates per depth were used for the required analyses. Sampling for the measurement of target parameters was performed prior to each aeration event (turning of the compost pile), also at the beginning and finishing the composting process. The samples were analyzed for parameters including moisture content (dried at 104°C for 24 h), pH, organic matter content, electrical conductivity (EC), total nitrogen (TN), microbial activity, and ammonium (NH_4^+) concentration. Table 1 shows selected characteristics of the fresh chicken manure used for the composting process.

Table 1. Characteristics of the fresh chicken manure used in this study

Character	Unit	Value
pH	-	6.5
EC	(dS m^{-1})	14.7
OM	(%)	32.6
Total N	(g kg^{-1})	16.4
NH_4^+	(g kg^{-1})	7.68
Microbial respiration	(mg C-CO_2 kg^{-1})	1103
Potassium	(%)	2.42
Phosphorus	(%)	1.05
Zinc	(mg kg^{-1})	380
Iron	(mg kg^{-1})	915

Temperature measurement

The pile temperature was measured daily over a period of 35 d. A digital probe thermometer with a 150 cm stem was used for these measurements. Four points at depths of 25, 50, 75, and 100 cm were selected within each composting pile for temperature monitoring. The thermometer probe was inserted to the specified depths, and the temperature was recorded once the reading stabilized. Some sources identify the appropriate measurement points as one-quarter of the distance from the pile's surface, one-quarter from the base, and the center of the pile (BCMAF, 1998; Rynk, 1992). Only data corresponding to the 75 cm depth are presented in the results section.

Moisture determination

To determine the moisture percentage, each sample was individually placed in a metal container and drying was performed in an oven at 80 °C for 48 h (Maurice, 2020).

Measurement of electrical conductivity (EC)

The content of soluble salts in the compost mass was determined by measuring its electrical conductivity. The procedure involved mixing a dried and ground (<2-mm) sample with distilled water (1:5 volume ratio), and electrical conductivity was measured in the extract using a conductivity meter (Model 644) (Maurice, 2020).

pH determination

To determine the pH, the dried and ground (<2-mm) sample was mixed with distilled water (1:5 ratio) in a plastic container, and left to stand for 24 h. A pH meter was used to measure the pH of the samples (Maurice, 2020).

Determination of organic matter content

The organic matter content of the samples was measured by wet oxidation method. In this method, potassium dichromate and concentrated H_2SO_4 was used to oxidize organic matter (Miller and Dick, 1995).

Measurement of the total nitrogen

The total amount of nitrogen in the compost samples was measured by using a distillation apparatus. In this method, 0.2 g of sample—previously ground and passed through a 1 mm sieve—was placed into nitrogen digestion tubes. The contents were digested for 2 h at 380 °C in the presence of 5 mL of H_2SO_4 and a mixture of $CuSO_4$, K_2SO_4, and selenium to convert the total nitrogen into ammonium sulfate. Subsequently, during the distillation stage, ammonia gas was converted into ammonium ions using boric acid, and the ammonium ions were quantified via titration with H_2SO_4 0.005 N (Keeney and Nelson, 1982).

Measurement of nitrate and ammonium

Nitrate and ammonium concentrations were measured using the method of Keeney and Nelson (1982). In this procedure, the dried samples (1.5 g) of compost were mixed with 15 mL KCl 2 M and shaken for one hour; following filtration through filter paper (Whatman # 42), the ammonium content of the samples was analyzed via steam distillation. For this purpose, the evolved ammonium was collected in a reagent containing boric acid, bromocresol green, and methyl red, and subsequently titrated with 0.005 N H_2SO_4. Magnesium oxide powder and a combination of Devarda's alloy and magnesium oxide powder were used to determine total inorganic nitrogen and ammonium nitrogen, respectively.

Assay of microbial respiration

Twenty g of the compost samples were placed in glass containers, and its moisture content was kept to 50% of its water-holding capacity using distilled water. Ten mL of 0.1 N NaOH solution was poured into test tubes, and one such tube was placed inside each glass container to capture the CO_2 generated by microbial respiration. The containers were then incubated at 25 ± 2°C for 72 h. The amount of CO_2 produced was captured by the NaOH solution and subsequently measured; for this purpose, 10 mL of barium chloride 10% was added to precipitate the carbonates formed. It was then titrated with 0.05 N H_2SO_4 in the presence of phenolphthalein indicator, and the amount of CO_2 produced by each treatment was determined by accounting for the acid consumed to neutralize the excess NaOH (Ajwa and Tabatabai, 1994).

Statistical analysis

This study was conducted using a split-plot design involving two factors: the carbon-to-nitrogen ratio and time. Excel 2013 software was used to plot the graphs, and the analysis of variance (ANOVA) was performed using SAS 9.1software.

3. Results

pH of the compost

As shown in Figure 1, during the first week, the highest pH in the composting poultry manure piles was observed at a carbon-to-nitrogen ratio of 25, while the lowest pH was recorded for the pile with a carbon-to-nitrogen ratio of 30. In the second week, no significant difference in pH was observed between the carbon-to-nitrogen ratios of 20 and 25; however, the lowest pH was associated with the pile having a carbon-to-nitrogen ratio of 30. In the third week, there was no significant difference in pH between the carbon-to-nitrogen ratios of 20 and 30, and the highest pH value was observed at a carbon-to-nitrogen ratio of 25. In the fourth week (W4), no significant difference was found between the carbon-to-nitrogen ratios of 20 and 25, whereas the pH of the pile with a carbon-to-nitrogen ratio of 30 was significantly less than that of the other ratios. Similarly, at week 5, the lowest pH was observed in the composting pile with a carbon-to-nitrogen ratio of 30.

In this study, the pH of the composting poultry manure piles increased as the composting process progressed. Over time, after decomposing and reducing the easily degradable organic matter, microbial activity—and consequently the CO_2 produced by the microbial population—declined; this factor led to a rise in the pH of pile. By the end of the process, the pH was risen to near-neutral levels (approximately 7.0) that is an index for the stabilization of the organic matter (Sesay *et al.*, 1997). In contrast with this result, Bustamante *et al.* (2008), reported a decrease in pH of the pile during composting of various animal manures resulting from reduced microbial activity and the consequent drop in CO_2 production (Bustamante *et al.*, 2008). The decrease in pH can be attributed to the release of organic acids and the incomplete oxidation of organic matter. The increase in pH results from ammonia production during material decomposition and the degradation of organic acids (Liu *et al.*, 2011). Similar to this result, Zhang *et al.* (2011) reported an elevated pH of compost due to the decomposition of organic acids and ammonia production.

EC of the compost

Increasing the carbon-to-nitrogen of the raw materials

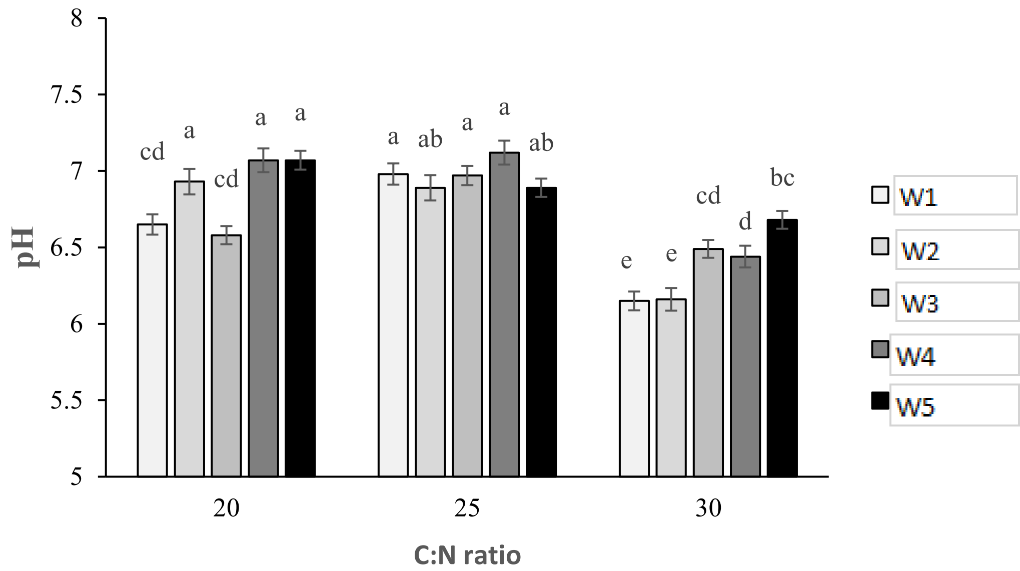

Figure 1. Changes in pH of poultry manure piles with varying initial carbon-to-nitrogen ratios at different sampling times. Columns with similar letters have no significant difference at $P < 0.05$. W1 to W5 presents week 1 to week 5 after starting the composting process.

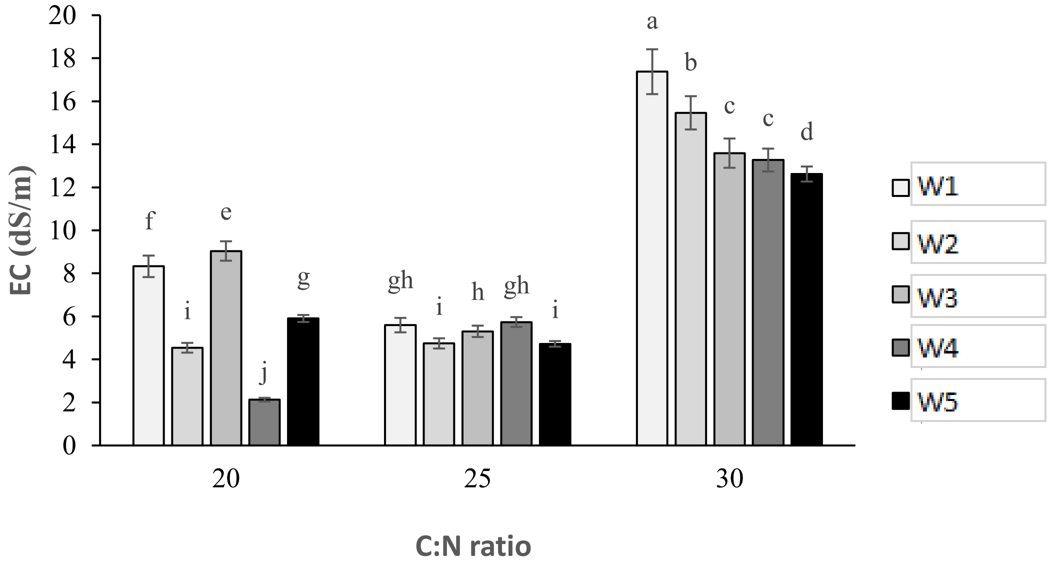

Figure 2. Changes in EC of poultry manure piles with varying initial C:N ratios at different sampling times. Columns with similar letters have no significant difference at $P < 0.05$. W1 to W5 presents week 1 to week 5 after starting the composting process.

resulted in higher electrical conductivity in the pile. At all the sampling times, the highest electrical conductivity was found at the piles with a C:N ratio of 30 (Figure 2). The EC of the composting poultry manure piles decreased over time. The lowest was recorded during the fourth week in the pile with a carbon-to-nitrogen ratio of 20. Rashed *et al.* (2010) and Zhang *et al.* (2011), in a similar study, reported that the reduction in electrical conductivity was attributable to the leaching of salts from the compost pile as well as the depletion of water-soluble substances, ammonia volatilization, and the potential precipitation of mineral salts during the composting process. Considering that the high salinity of fresh poultry manure is a major constraint on its application to agricultural land, composting the manure—which reduces its salinity—creates favorable conditions for its use. Therefore, a C:N ratio of 25 is suitable when lower salinity levels are desired.

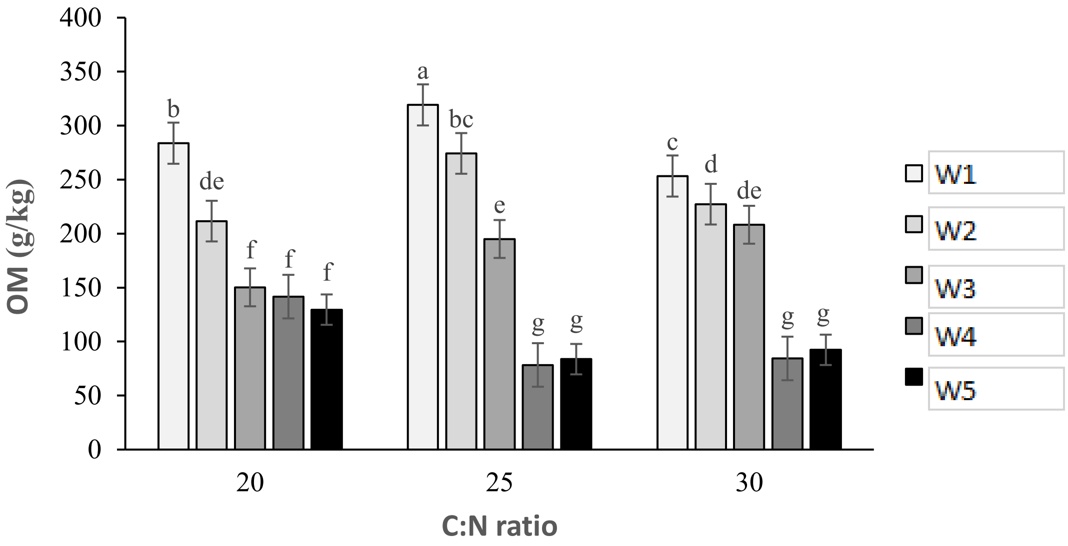

Figure 3. Changes in organic matter content of poultry manure piles with varying initial C:N ratios at different sampling times. Columns with similar letters have no significant difference at $P < 0.05$. W1 to W5 presents week 1 to week 5 after starting the composting process.

OM of the compost

During the first and second weeks, the compost mass with a carbon-to-nitrogen ratio of 25 exhibited the highest organic matter content (Figure 3). A similar trend regarding changes in organic matter content across the different treatments was observed in the second week as in the first. Over the subsequent three weeks, the organic matter content in the mass with a carbon-to-nitrogen ratio of 20 was greater than in the other two carbon-to-nitrogen ratios.

In this study, the organic matter content of the composting poultry manure piles decreased from the onset of the process up to week 4 and then remained constant up to week 5, indicating compost maturity. The reduction in organic matter during the process may be attributed to a higher decomposition rate and intensified mineralization driven by microbial activity (Gadikota, 2021). Following the consumption and breakdown of readily decomposable materials, substances that are resistant to decomposition and require longer periods to break down accumulated, thereby leading to a decline in the activity of decomposing microorganisms. In the short term, the rate of organic carbon mineralization depends on the amount of water-soluble carbon present (Gadikota, 2021). This fraction of organic matter is consumed and rapidly depleted during the initial stages of decomposition. The removal of soluble substances and the accumulation of recalcitrant compounds lead to a reduction in the rate of decomposition during subsequent stages (Paré *et al*., 1998; Sall *et al*., 2007). In agreement with result, Bansal *et al*. (2000) reported a decrease in organic matter of cattle manure compost due to microbial mineralization. After finishing the period of composting, the amount of organic matter of the piles ranged from 9% to 13%. According to Gotaas's theory, the appropriate organic matter content for compost should be between 25% and 50%, whereas the World Health Organization recommends a range of 10% to 20% (Omrani, 2004).

The total N content of the compost

In the first week, the total nitrogen content in the pile with a carbon-to-nitrogen ratio of 30 was higher than in the other two piles with lower C:N ratios (Figure 4). No significant difference in the total N content was observed among the piles with various carbon-to-nitrogen ratios during the second and third weeks. As the carbon-to-nitrogen ratio of the raw materials increased, the total nitrogen content of the pile increased (Figure 4).

In this study, the total nitrogen content of the composting poultry manure piles decreased over the time. It is likely that, over time—and due to practices such as watering the piles to maintain necessary moisture levels—a portion of the soluble nitrogen leached out of the piles, resulting in a loss of N. Poultry manure contains a significant amount of nitrogen (approximately 80%) in the form of uric acid and urea. Uric acid and urea are rapidly converted into NH_3 and CO_2 by the enzyme urease, with more than 60% of the ammonia being lost in gaseous form (Mahimairaja *et al*., 1994). The pH is a key factor which influences the extent of nitrogen loss; specifically, higher amounts of nitrogen are emitted as ammonia gas under alkaline pH conditions (Hartenstein, 1981).

In the present study, the pH of the compost mass increased over time; consequently, ammonia emission and

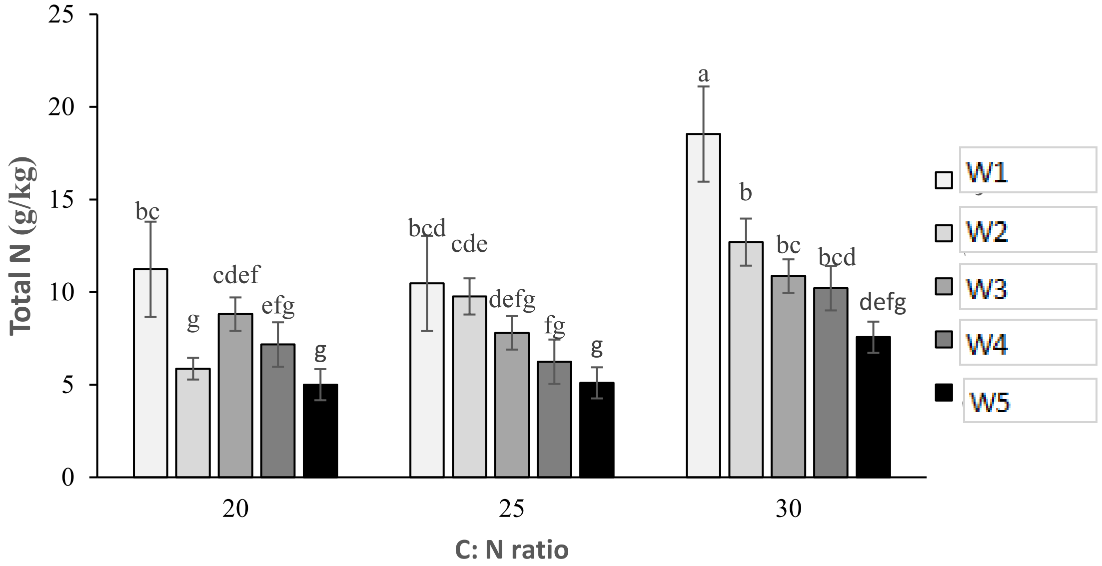

Figure 4. Changes in total N concentration of poultry manure piles with varying initial C:N ratios at different sampling times. Columns with similar letters have no significant difference at $P < 0.05$. W1 to W5 presents week 1 to week 5 after starting the composting process.

nitrogen loss rose, while the total nitrogen content decreased. Harmsen and Van Schreven (1995) stated that a nitrogen concentration of approximately 15 to 20 g/kg (corresponding to a carbon-to-nitrogen ratio of 20 to 25) results in net nitrogen mineralization, whereas net nitrogen immobilization is expected at lower nitrogen concentrations (Harmsen and Van Schreven 1995). In this study, nitrogen loss was greater in compost masses with C:N ratios of 20 and 25 compared to those with a C:N ratio of 30. Most researchers, for example Paul and Clark (1996), believe that net nitrogen mineralization occurs when the C:N ratio of organic matter is less than 25. In fact, organic matter with a C:N ratio greater than 25 is more resistant to microbial decomposition (Malhi *et al*., 2005).

NH_4^+ concentration of the compost

During the first week, the ammonium content in the mass with a carbon-to-nitrogen ratio of 30 was greater than in the other two levels (Figure 5). No significant difference in ammonium concentration was observed between the treatments with C:N ratios of 20 and 25. The same trend was found in the subsequent weeks. Overall, higher ammonium levels were observed in the mass as the carbon-to-nitrogen ratio increased. The highest ammonium level was recorded in the first week, and the lowest in the fifth week (Figure 5). Benito *et al*. (2003) stated that the decrease in ammonium concentration is due to its conversion into nitrate or the loss of ammonium as ammonia gas. As previously mentioned, the pH of the mass increased over time, providing more favorable conditions for ammonia volatilization.

Microbial respiration of the compost

During the first week, higher microbial respiration was found in the composting poultry manure pile with a carbon-to-nitrogen ratio of 30 in comparison with those with carbon-to-nitrogen ratio of 20 and 25 (Figure 6). The microbial respiration was approximately similar between the piles with carbon-to-nitrogen ratios of 20 and 25. In the second week, microbial respiration was the highest in the treatments with carbon-to-nitrogen ratios of 25 and 30. During the third, fourth, and fifth weeks, microbial respiration was similar among the piles with different carbon-to-nitrogen ratios. In fact, over the final three weeks, no significant difference in microbial respiration was found among the various carbon-to-nitrogen ratios.

Overall, during the composting process, the highest level of microbial respiration was observed in week 2 and in piles with C:N ratios of 25 and 30 (Figure 6). The results of this study are fully consistent with previous findings; for example, Ajwa and Tabatabai (1994) demonstrated that organic carbon mineralization was reduced by time, indicating a decrease in the microbial population. More than 50% of the carbon evolved during 30-d incubation is released within the first six days. Comparing seven kinetic models of organic carbon mineralization during a 6-month incubation experiment by using 17 types of organic residues (e.g., plant residues, animal residues, compost, and organic manure), Torres *et al*. (2001) concluded that the cumulative trend of carbon mineralization over time followed an exponential pattern across the treatments.

4. Conclusions

The main question addressed in this study was whether

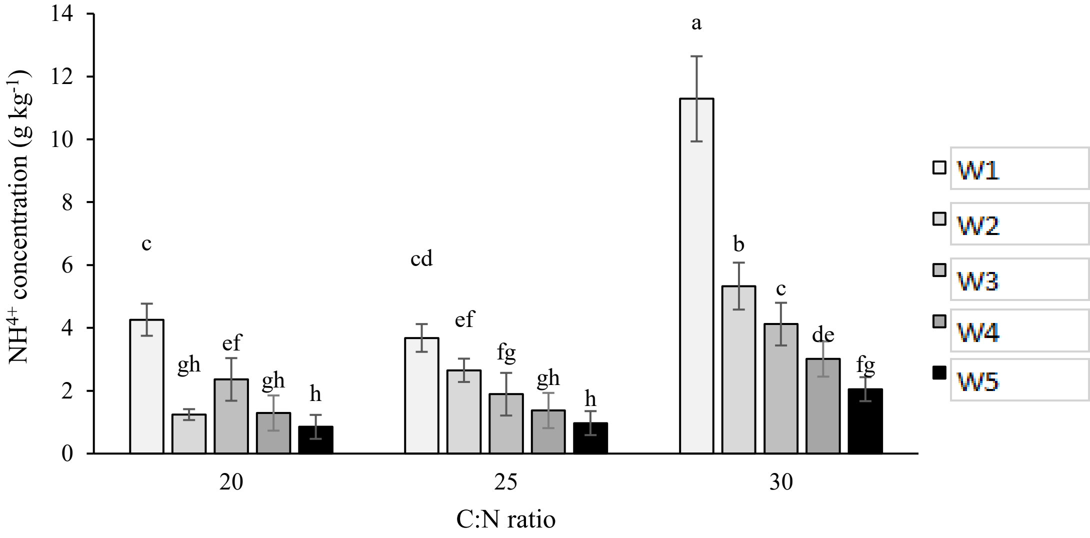

Figure 5. Changes in NH_4^+ concentration of poultry manure piles with varying initial C:N ratios at different sampling times. Columns with similar letters have no significant difference at $P < 0.05$. W1 to W5 presents week 1 to week 5 after starting the composting process.

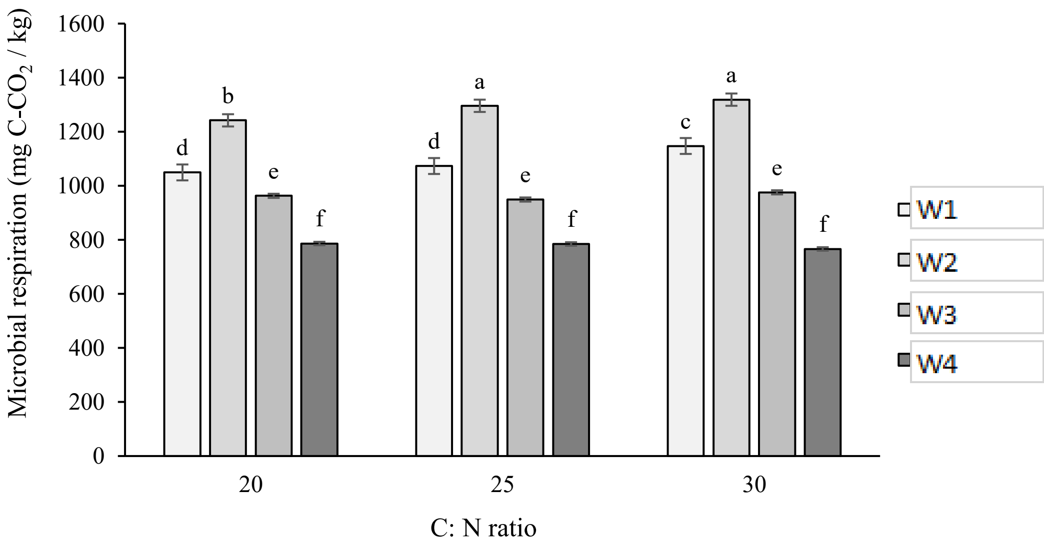

Figure 6. Changes in microbial respiration of poultry manure piles with varying initial C:N ratios at different sampling times. Columns with similar letters have no significant difference at $P < 0.05$. W1 to W4 presents week 1 to week 4 after starting the composting process.

varying carbon-to-nitrogen ratios in poultry manure mixtures containing sawdust would affect the properties of the resulting compost. The results indicated that the effects of carbon-to-nitrogen ratios of 20 and 25 on the measured properties were nearly identical; the highest values for pH, organic matter content, nitrogen loss, and ammonia emission were found at a carbon-to-nitrogen ratio of 25, whereas the lowest values were recorded at a carbon-to-nitrogen ratio of 30. It can be concluded that based on the physical, chemical, and biological conditions of the agricultural soil and the specific crop, the properties of compost derived from poultry manure can be largely tailored by optimize the carbon-to-nitrogen ratio; this enhances productivity while offering significant savings in both cost and time. In further research, it is recommended that other carbon-enriched materials—such as rice husks and straw—also be utilized to achieve various carbon-to-nitrogen ratios. The site-specific nature of this approach becomes very important considering that there may be considerable variability in soil properties like organic carbon content, salinity, pH, texture, and availability of nutrients in the agricultural soils (Rezaie *et al,*. 2026).

References

Ajwa, H. and M. Tabatabai. 1994. Decomposition of different organic materials in soils. *Biol. Fert. Soils.* 18: 175-182

British Columbia Ministry of Agriculture and Food (BCMAF). 1998. *Agricultural Composting Handbook Resource Management Branch*, British Columbia Ministry of Agriculture, Food and Fisheries, BC.

Benito, M., A. Masaguer, R. D. Antonino and A. Moliner. 2005. Use of pruning waste compost as a component in soilless growing media. *Bior. Tech*. 96: 597-603

Bustamante, M. A., C. Paredes, F. C. Marhuenda-Egea, A. Pérez-Espinosa, M. P. Bernal and R. Moral. 2008. Co-composting of distillery wastes with animal manures: Carbon and nitrogen transformations in the evaluation of compost stability. *Chemosphere*. 72(4): 551-557.

Calderon, F. J., G. W. McCarty and J. B. Reeves. 2005. Analysis of manure and soil nitrogen mineralization during incubation. *Biol. Fert. Soils*. 41(5): 328-336.

Eghball, B., J. F. Power, J. E. Gilley and J. W. Doran. 1997. Nutrient, carbon and mass loss during composting of beef cattle feedlot manure. *Environ. Qual*. 26: 189-193.

Foth, H. D. and B. G. Ellis. 1998. *Soil Fertility*. John Wiley & Sons, New York. USA.

Levi-Minzi, R., R. Riffaldi and A. Saviozzi. 1986. Organic matter and nutrients in fresh and mature farmyard manure. *Agricultural Wastes*. 16(3): 225-236.

Haga, K. 1999. Development of composting technology in animal waste treatment-review. *Asian Australas J. Anim. Sci*. 12: 604–606.

Harmsen, G. W. and D. A. Van Schreven. 1995. Mieralization of organic nitrogen in the soil. *Adv. Agron*. 7: 299-398.

Hartenstein, R. 1981. Production of earthworms as a potentially economical source of protein. *Biotechnol. Bioeng*. 23(8): 1797-1811.

Gadikota, G. 2021. Carbon mineralization pathways for carbon capture, storage and utilization. *Commun. Chem.* 4, 23.

Keeney, D. and D. Nelson. 1982. *Nitrogen-Inorganic Forms. Methods Of Soil Analysis Part 2 Chemical And Microbiological Properties*. 643-698.

Kumar, M., L. OuYan and J. G. Lin. 2010. Co-composting of green waste and food waste at low C/N ratio. *Waste Manage*. 30: 602-60.

Liu, D., R. Zhang, H. Wu, D. Xu, Z. Tang, G. Yu and Q. Shen. 2011. Changes in biochemical and microbiological parameters during the period of rapid composting of dairy manure with rice chaff. *Bior. Tech*. 102(19): 9040-9049.

Lyimo, H. J. F., R. C. Pratt, R. S. O. W. Mnyuku. 2012. Composted cattle and poultry manures provide excellent fertility and improved management of gray leaf spot in maize. *Field Crop Res*.126: 97-103.

Mahimairaja, S., N. S. Bolan, M. J. Hedley and A. N. Macgregor. 1994. Losses and transformation of nitrogen during composting of poultry manure with different amendments: an incubation experiment. *Bior. Tech*. 47: 265-275.

Malhi, S. S., Z. H. Wang, C. M. Monreal and J. T. Harapik. 2005. Nitrogen fertilization effects on quality of organic matter in a grassland soil. *Nutr. Cycl. Agroecosys*. 73: 191-199.

Maurice, E. 2020. Testing compost. Ohio state university fact sheet- Agriculture and natural resources. Extension solid specialist at: www.Ohioline.osu.edu .

Miller, M. and R. P. Dick. 1995. Dynamics of soil C and microbial biomass on whole soil and aggregate in two cropping systems. *Appl. Soil Ecol*. 2: 253-261.

Omrani, G. A. 2004. *Solid Wastes*. 2th ed., Tehran: Islamic Azad University Publishing. P: 31-37.

Paré, T., H. Dinel, M. Schnitzer and S. Dumontet. 1998. Transformations of carbon and nitrogen during composting of animal manure and shredded paper. *Biol. Fert. Soils*. 26: 173-178.

Paul, E. A. and F. E. Clark. 1996. *Soil Microbial and Biochemistry*, 2th ed., Academic Press, San Diego.

Rashad, F. M., W. D. Saleh and M. A. Moselhy. 2010. Bioconversion of rice straw and certain agro-industrial wastes to amendments for organic farming systems: 1. Composting, quality, stability and maturity indices. *Bior. Tech*. 101(15): 5952-5960.

Rezaei, H., Esmaeelnejad, L. and Mirkhani, R. (2026). Spatial variability and delineation of soil fertility management zones using geostatistics and fuzzy c-means clustering in an irrigated wheat system in Alborz province, Iran. Dryland Soil Research (DLSR).

Rynk, R. 1992. *On Farm Composting Hand Book*. Northeast Regional Agricultural Engineering Service. Available From NRAES, cooperative Extension, 152 Riley – Robb Hall, Ithaca, NY 14853-5701(607)255-7654.

Sall, S., I. Bertrand, J. L. Chotte and S. Recous. 2007. Separate effects of the biochemical quality and N content of crop residues on C and N dynamics in soil. *Biol. Fert. Soils*. 43: 797-804.

Sesay, A. A., K. Lasaridi, E. Stentiford and T. Budd. 1997. Controlled composting of paper pulp sludge using the aerated static pile method. *Compost Sci.Util.* 5(1): 82-96.

Thuries, L., M. Pansu, C. Feller, P. Herrmannb and J. C. Remy. 2001. Kinetics of added organic matter decomposition in a Mediterranean sandy soil. *Soil Biol. Biochem*. 33: 997-1010.

Zhang, J., G. Zeng, Y. Chen, M. Yu, Z. Yu, H. Li and H. Huang. 2011. Effects of physico-chemical parameters on the bacterial and fungal communities during agricultural waste composting. *Bior. Tech.* 102(3): 2950-2956.