PREPARATION OF COMPOST FROM LIGNOCELLULOSIC WASTE AND ITS EFFECT ON SOIL PROPERTIES COMPARED WITH UREA AND COMPOST PREPARED FROM DOMESTIC WASTE

Laxmi Ahlawat[1], Brijesh Shivhare[2*]
[1]Research Scholar, Botany, Faculty of Sciences, Baba Mastnath University, Rohtak, 124021; Email: laxmiahlawat23@gmail.com
[2*]Assistant Professor, Botany, Faculty of sciences, Baba Mastnath University, Rohtak, 124021; brijesh@bmu.ac.in
***Corresponding author:** Brijesh Shivhare, Assistant Professor, Botany, Faculty of sciences, Baba Mastnath University, Rohtak, 124021; brijesh@bmu.ac.in

Abstract

The reliance on chemical fertilizers and amount of agricultural waste produced worldwide has been rapidly rising in recent years. The production of large amounts of lignocellulose-containing wastes poses a serious environmental contamination risk and soil health challenges because people usually burn this residue. In future negative impacts may cause global climate changes, depletion of soil nutrients, low agriculture productivity, increment in respiratory problems and many more. The main objectives of this research are to prepare compost of different composition i.e. one from lignocellulosic waste like crop residue and another from dung and domestic waste and evaluate its effect on soil properties in comparison with urea. A soil application experiment was conducted using different treatments, including lignocellulosic waste compost, domestic waste compost, urea, and an untreated control. In our study we compared the carbon content, pH, electrical conductivity and nutrient profile of soil pre and post application of both composts and urea. The results indicated that application of lignocellulosic waste compost significantly enhanced soil organic carbon content and nutrient availability compared to urea-treated soils. When compared with domestic waste compost, lignocellulosic waste compost showed superior performance in improving soil fertility, with the added advantage of lower contamination risk and greater stability. The study also highlighted reduced nutrient losses in soils amended with lignocellulosic waste compost.
Keywords – Soil properties, composting, Lignocellulosic waste, sustainable agriculture, soil fertility management
How to cite this article: Ahlawat L, Shivhare B. Preparation of Compost from Lignocellulosic Waste and Its Effect on Soil Properties Compared with Urea and Compost Prepared from Domestic Waste. Int J Drug Deliv Technol. 2026;16(70s): 1004-1009. DOI: 10.25258/ijddt.16.70s.106

1. Introduction

The main source of production is agriculture. The most significant crops grown in Punjab and Haryana each year are rice and wheat. During harvesting, a significant amount of residue known as stubble is produced in addition to the desired crop. Additionally, farmers often favour the straightforward method of burning the waste produced along with the harvested crop on the fields themselves because there is so little time between rice harvest and wheat sowing season. Consequently, the method is called stubble burning (Laxmi & Shivhare, 2025). However, it has numerous detrimental impacts on soil, such as lowering fertility and organic matter, and it also pollutes the environment, which is bad for living beings. It became necessary to control burning of crop residue (Ansari et al., 2023). A vital natural resource, soil promotes food security, ecosystem stability, and agricultural output. In present-day agriculture, maintaining soil fertility while reducing environmental degradation has emerged as a significant concern (Jethva et al., 2019). Chemical fertilisers, especially nitrogenous fertilisers like urea, have greatly boosted agricultural yields over the past few decades. However, their long-term and careless use has had negative impacts on the ecosystem and soil health. Continuous urea application has been connected to soil acidification, nutritional imbalance, decreased soil organic matter, and decreased soil microbial diversity, all of which have an impact on crop yield and soil sustainability (Savci, 2012). Interest in alternate nutrient management techniques that support sustainable agriculture has increased as a result of these worries.

Composting provide a very useful and cost effective alternative to manage this waste. Composting is the biological process by which a variety of microorganisms, including actinomycetes, bacteria, and fungus, transform the solid waste of plant and animal organic materials into a fertile matrix in the presence of oxygen. A solid waste can be transformed into compost or a variety of by-products, such as heat, water, and CO2, by adding a variety of microorganisms (Zhang et al., 2022). After the microbiological process, humus is the stable, solid foundation that may be applied to land as an organic fertiliser to improve soil fertility and structure.

2. Composting Stages

2.1 Hot Phase (Mesophilic Phase)

Composting processes undergo four stages: mesophilic, thermophilic, cooling, and compost maturation. The composting process begins at room temperature and reaches 45°C in just a couple of days or even hours. As different heterogeneous groups of microorganisms use the nitrogen and carbon from organic materials for their own body absorption, their metabolic activity raises the temperature. When soluble substances like sugars break down, organic acids are produced, this causes the pH to decrease (to around 4.0 or 4.5). The duration of the heat phase is two to eight days (Waqas et al., 2023).

2.2 Curing Phase (Thermophilic and Hygienization Phase)

The mesophilic microorganisms are replaced by thermophilic microorganisms (mostly thermophilic bacteria) that can survive at higher temperatures when the temperature of the parent organic material reaches 45°C. These thermophilic microbes aid in the breakdown of cellulose and lignin, two complex organic materials. The compost pile's pH rises during this phase as a result of the thermophilic microorganism's conversion of nitrogen to ammonia (FAO, 1980 and 2020). The compost pile's high temperature during this stage aids in the destruction of pollutants and germs that come from faeces, such as Salmonella sp. and Escherichia coli. This stage is also referred to as the hygienization phase since it includes helminth cysts and eggs, phytopathogen fungus spores, weed seeds, etc (Meena et al., 2021).

At the same time, this stage is highly advantageous since high temperatures (over 55°C) aid in the removal of phytopathogen fungus spores, helminth cysts, weed seeds, and any other dangerous bacteria that may have been present in the parent material and produce a hygienic end product (Waqas et al., 2023).

2.3 Cooling or Mesophilic Phase II

The temperature of the pile drops to roughly 40 to 45°C once the carbon and nitrogen sources from the composting material have been exhausted. During the mesophilic phase, cellulose continues to degrade polymers, and certain fungi that are visible to the naked eye emerge. Mesophilic organism activity resumes and the compost pile's pH gradually drops as the temperature drops below 40°C, while the pH of the compost pile generally stays slightly alkaline (Alokika et al., 2023). Certain fungus has the ability to grow and even create structures that are visible. This chilling phase, which takes a few weeks, can be mistaken for the maturation phase (Waqas et al., 2023).

2.4 Maturation Phase

The compost pile's temperature decreases to room temperature (20–30ºC) during the maturation phase, which also sees the condensation of carbonaceous chemicals and polymerisation that aids in the formation of fulvic and humic acids (Waqas et al., 2023).

3. Materials and Methods

3.1 Collection of raw materials

Agriculture waste material like crop residue, green and dry leaves of plants, fruit and vegetable peels, rice husk, dung, other domestic waste like rotten food etc. (Fig.1) were collected from Dighal village, Jhajjar district, Haryana, India, for preparation of compost during April 2025. Dung was sun-dried for 2 weeks. Crop residue intended for lignocellulosic waste compost was pounded and sieved with 60 sieve size mesh to get it in powder form (Arokiyaraj et al., 2024).

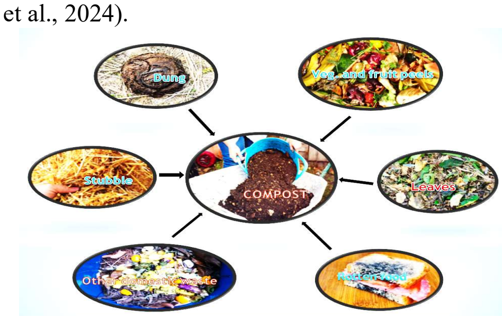

Fig.1 Raw material used for compost preparation

3.2 Compost Preparation

2 wooden bins named A, B (size 76.3cm) were used for compost preparation and trench of suitable size of bins were made in soil surface. The composting trench was made away from trees to reduce the chance of interruption of roots growing into the composting material. Bottom of bins was in direct contact of soil to seep the liquid of decomposing organic matter and better involvement of microbes. Aeration holes were made at top of bin to maintain adequate air supply and to protect compost from pests and entry of any foreign material. Bin A was filled with lignocellulosic agricultural waste and bin B contains biodegradable domestic waste. Only biodegradable organic materials were used for

composting whereas non-biodegradable material such as plastics, bones, dairy products etc. were excluded (Awasthi et al., 2021).

3.3 Compost Management

During decomposition, the bin were turned over regularly, in order to keep it well aerate, prevent bad odour and promote uniform decomposition and prevent anaerobic conditions. The first turning was carried out after 2 weeks. The second turning overtook that after 2 week, followed by third turning after one week. Thereafter each turning was performed weekly until compost maturity. Compost temperature was monitored regularly to ensure optimum microbial activity and prevent excessive heating during initial thermophilic phase as it should start being at normal range as the process is 50% complete.

During the process, water was sprinkled over the bin, as or if necessary to maintain optimum moisture level. The lignocellulosic compost of bin A matured after approximately 4.2months, where the domestic waste compost of bin B required approximately 7months for complete decomposition. Mature compost was dark brown in colour with no unpleasant odour. However some stalks remained partially decomposed due to their high lignin content and can still be seen in bin A (Rich et al., 2018, Awasthi et al., 2021).

3.4 Experimental Design

The experiment was conducted with four treatments applied to soil of 4 different equally divided areas (50 m^2 each). The treatment consisted of T_0 (No treatment), T_1 (Lignocellulosic waste compost), T_2 (Domestic waste compost), T_3 (Urea). The effects of treatments on soil of selected areas were evaluated under identical field conditions.

3.5 Soil Analysis

After completion of experiment, soil samples were collected from each plot for analysis. Soil Organic Carbon was estimated using the Walkley and Black titration method (Souza et al., 2025). Soil pH was measured using a pH meter in a 1:2 soil–water suspension (Najdenko et al., 2024). Electrical Conductivity (EC) was measured using a conductivity meter in the same soil extract prepared for pH estimation (Senila & Kovacs, 2024). The concentration of available soil nutrients like Phosphorus (P), Sulphur (S), Zinc (Zn), Boron (B), Manganese (Mn), Iron (Fe), Copper (Cu) and Potassium(K) was analysed using standard soil analysis methods (El Behairy et al., 2024)

4. Results and discussion

The application of different treatment clearly demonstrates significant variations in soil properties under different nutrient management practices. The results obtained for each treatment are presented and discussed below.

4.1 Soil organic carbon (SOC)

As shown in Table 1, Domestic waste compost treatment (T_2) adds more organic carbon to soil (0.72%) followed by lignocellulosic waste compost treatment (T_1) which is 0.63%. The control treatment (T_0) showed an intermediated value (0.51%); whereas urea treated soil (T3) recorded the lowest SOC content(0.24%).

Table1. Effect of different treatments on SOC, EC and pH

Sr.no	Treatments	SOC (%)	EC(dS m^{-1})	pH
1.	T_0	0.51%	0.27	8.1
2.	T_1	0.63%	0.29	7.1
3.	T_2	0.72%	0.48	7.6
4.	T3	0.24%	0.68	6.8

Use of urea can improves immediate plant growth, but does not build carbon reserves in soil. Urea supplies nitrogen but contains no organic carbon. Use of domestic waste compost contributes to enhance soil fertility by improving SOC. These findings indicate that application of compost in soil is more effective in improving SOC than urea.

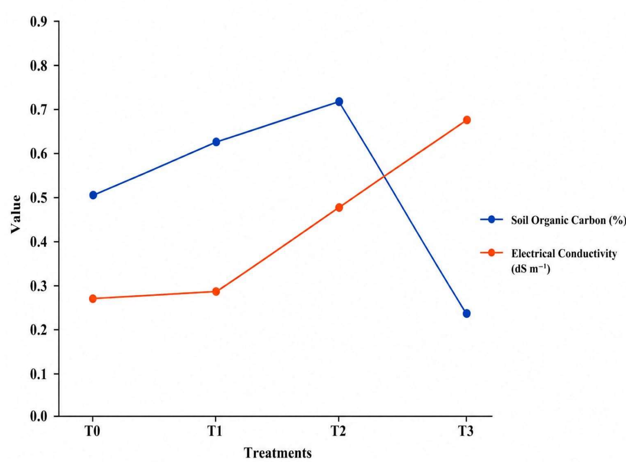

Fig. 2 Comparative analysis of EC and SOC in different treatments

4.2 Soil electrical conductivity

As shown in Table 1, the highest soil EC was recorded in urea treated soil (T_3) which is (0.68 dS m^{-1}) followed by domestic waste compost treatment (T_2) with a value of 0.48 dS m^{-1}. The lignocellulosic waste compost treatment (T_1) showed a slight increment (0.29 dS m^{-1}) compared with control (T_0) with a EC value of 0.27 dS m^{-1}. The relatively low EC observed under control treatment T_0 and T_1 maintains the most stable and favorable EC levels due to its slow nutrient release and low salt content. Urea causes rapid EC fluctuations, increasing the risk of osmotic stress, while domestic waste compost tends to raise EC more substantially due to its higher soluble salt concentration (Gondek et al., 2020).

4.3 Soil pH

Table 1 shows that control treatment (T_0) recorded the highest pH (8.1), whereas the urea-treated soil (T_3) showed the lowest pH (6.8). The lignocellulosic waste compost treatment (T_1) maintained a near-neutral pH (7.1), while the domestic waste compost treatment (T_2) resulted in a moderately alkaline pH (7.6). These findings indicate that lignocellulosic compost maintained a soil pH closer to neutral than other treatment which is generally considered favourable for nutrient availability in soil so it contribute to soil health.

4.4 Soil nutrient availability

As presented in Table 2, the lignocellulosic waste compost treatment (T_1) recorded the highest concentrations of available phosphorus (23.6 kg ha^{-1}), potassium (306 kg ha^{-1}), sulphur (23.2 kg ha^{-1}), zinc (1.14 kg ha^{-1}), boron (0.69 kg ha^{-1}), and manganese (9.4 kg ha^{-1}), indicating its superior ability to improve soil fertility. The domestic waste compost treatment (T_2) also enhanced nutrient availability compared with the control (T_0), although the improvements were lower than those observed under lignocellulosic compost. The highest available nitrogen content was recorded in the urea treatment (T_3; 290 kg ha^{-1}), reflecting the rapid release of inorganic nitrogen from urea. However, the concentrations of other nutrients remained comparatively lower than those observed in T_1 and T_2 treatments.

Table 2.Effect of different treatments on soil nutrient availability

Treatments	**Phosphorus** (kg ha^{-1})	**Potassium** (kg ha^{-1})	**Nitrogen** (kg ha^{-1})	**Sulphur** (kg ha^{-1})	**Zinc** (kg ha^{-1})	**Boron** (kg ha^{-1})	**Manganese** (kg ha^{-1})
T_0	13.1	188	224	12.8	0.71	0.46	6.1
T_1	23.6	306	251	23.2	1.14	0.69	9.4
T_2	20.3	285	239	16.2	0.99	0.58	8.3
T_3	13.9	192	290	9.7	0.67	0.49	6.4

This suggests that although urea effectively supplies nitrogen, it contributes less to the overall improvement of soil fertility than organic amendments. The superior performance of lignocellulosic waste compost may be attributed to its gradual decomposition, continuous nutrient release, and improvement of soil organic matter, which enhances nutrient retention and microbial activity. These findings indicate that lignocellulosic waste compost provides a more balanced and sustainable improvement in soil nutrient status than domestic waste compost or urea alone.

5. Conclusion

The comparative study clearly indicates that compost prepared from both lignocellulosic and domestic waste is more effective than urea in improving soil pH balance, nutrient quality, electrical conductivity, and soil organic carbon. Lignocellulosic waste compost proved superior for long-term soil carbon enrichment, while domestic waste compost enhanced immediate nutrient availability. Domestic waste compost also improved soil fertility but was less effective than lignocellulosic compost in maintaining long-term soil health. Therefore, lignocellulosic waste compost can be considered a sustainable alternative to chemical fertilizers for improving soil fertility, enhancing nutrient availability, and promoting environmentally friendly management of agricultural residues. Further long-term field studies are recommended to evaluate its performance under different soil and climatic conditions.

REFERENCES

Abrol, V., Sharma, P., Chary, G. R., et al. (2024). Integrated organic and mineral fertilizer strategies for achieving sustainable maize yield and soil quality in dry sub-humid Inceptisols. *Scientific Reports, 14*, 27227.

Adugna, G. (2016). A review on impact of compost on soil properties, water use and crop productivity. *Agricultural Science Research Journal, 4*(3), 93–104.

Alokika, Anu, & Singh, B. (2023). Utilization of lignocellulosic plant residues for compost formation and its role in improving soil fertility. *Pedosphere, 33*(5), 700–716

Ansari, S. A., Shakeel, A., Sawarkar, R., Maddalwar, S., Khan, D., & Singh, L. (2023). Additive facilitated co-composting of lignocellulosic biomass waste: Approach towards minimizing greenhouse gas emissions—An up-to-date review. *Environmental Research, 224*, 115529.

Arokiyaraj, S., Rajakrishnan, R., & Flanetraj, S. R. (2024). Sustainable composting of vegetable waste, cow dung, grasses, and food wastes into soil amendment using starter culture and growth characteristics in guava plant. *BioResources, 19*(3), 5610–5631.

Awasthi, M. K., et al. (2021). Influence of microbial inoculants on co-composting of lignocellulosic crop residues with farm animal manure: A review. *Bioresource Technology, 337*, 125492.

El Behairy, R. A., El Arwash, H. M., El Baroudy, A. A., Ibrahim, M. M., Mohamed, E. S., Kucher, D. E., & Shokr, M. S. (2024). How can soil quality be accurately and quickly studied? A review. *Agronomy, 14*(8), 1682.

Farooqi, Z. U. R., Qadir, A. A., Khalid, S., et al. (2024). Greenhouse gas emissions, carbon stocks, and wheat productivity following biochar, compost and vermicompost amendments: Comparison of non-saline and salt-affected soils. *Scientific Reports, 14*, 7752.

Goldan, E., Nedeff, V., Barsan, N., Culea, M., Panainte-Lehadus, M., Mosnegutu, E., Tomozei, C., Chitimus, D., & Irimia, O. (2023). Assessment of manure compost used as soil amendment: A review. *Processes, 11*(4), 1167.

Gondek, M., Weindorf, D. C., Thiel, C., & Kleinheinz, G. (2020). Soluble salts in compost and their effects on soil and plants: A review. *Compost Science & Utilization, 28*(2), 59–75.

Jethva, H., Torres, O., Field, R. D., Lyapustin, A., Gautam, R., & Kayetha, V. (2019). Connecting crop productivity, residue fires, and air quality over northern India. *Scientific Reports, 9*, 16594.

Laxmi, & Sivhare, B. (2025). Harmful effects of burning crop residue and management approach to reduce stubble burning. In *Advanced Applied Research in Agriculture, Food and Plant Science* (pp. 38–60). ISBN 978-93-47068-84-3.

Meena, A., Karwal, M., Dutta, D., & Mishra, P. (2021). Composting: Phases and factors responsible for efficient and improved composting. *Agriculture and Food E-Newsletter, 3*, 93–97.

Najdenko, E., Lorenz, F., Dittert, K., & Olfs, H.-W. (2024). Rapid in-field soil analysis of plant-available nutrients and pH for precision agriculture: A review. *Precision Agriculture, 25*, 3189–3218.

Patel, A., Mehta, R., & Joshi, D. (2019). Comparative study of domestic waste compost and synthetic fertilizers on soil nutrient status. *Environmental Sustainability Journal, 15*(1), 34–42.

Rashid, M., & Bano, A. (2020). Effects of urea and organic amendments on soil chemical properties. *International Journal of Agricultural Sciences, 12*(4), 121–130.

Rich, N., Bharti, A., & Kumar, S. (2018). Effect of bulking agents and cow dung as inoculant on vegetable waste compost quality. *Bioresource Technology, 252*, 83–90.

Sánchez, E., Rodríguez, A., & González, J. L. (2019). Urea fertilization and soil pH dynamics: A review. *Soil Science Society of America Journal, 83*(5), 123–132.

Savci, S. (2012). An agricultural pollutant: Chemical fertilizer. *International Journal of Environmental Science and Development, 3*(1), 73–80.

Senila, M., & Kovacs, E. (2024). Use of diffusive gradients in thin-film technique to predict the mobility and transfer of nutrients and toxic elements from agricultural soil to crops: An overview of recent studies. *Environmental Science and Pollution Research, 31*, 34817–34838.

Singh, J., Kumar, V., & Choudhary, P. (2021). Organic amendments from agricultural residues: Implications for soil fertility and productivity. *Soil Research, 59*(7), 657–667.

Singh, Y. P., Arora, S., & Mishra, V. K. (2023). Composting of municipal solid waste using earthworms and ligno-cellulolytic microbial consortia for reclamation of degraded sodic soils and harnessing their productivity potential. *Sustainability, 15*(3), 2317.

Souza, A. S., et al. (2025). Quantifying terrestrial carbon in the context of climate change: A review of common and novel technologies and methods. *Carbon Balance and Management, 20*, Article 316.

Sunil Kumar, Garhwal, R. S., Dinesh Kumar, A., & Pal, D. (2024). Effect of different nutrient management practices on soil available macronutrients (NPK) in rice–wheat cropping system. *International Journal of Research in Agronomy, 7*(2), 327–329.

Waqas, M., Hashim, S., Humphries, U. W., Ahmad, S., Noor, R., Shoaib, M., Naseem, A., Hlaing, P. T., & Lin, H. A. (2023). Composting processes for agricultural waste management: A comprehensive review. *Processes, 11*, 731.

Zhang, H., Li, Y., & Wang, X. (2022). Influence of lignocellulosic biomass compost on soil carbon and nutrient dynamics. *Applied Soil Ecology, 170*, 104348.

Zhang, S., Chen, X., Shi, A., Xu, M., Zhang, F., Zhang, L., Zang, J., Xu, X., & Gao, J. (2025). Effect of compost addition on carbon mineralization and kinetic characteristics in three typical agricultural soils. *Agronomy, 15*(7), Article 1559.

Żukowska, G., Mazurkiewicz, J., Myszura, M., & Czekała, W. (2019). Heat energy and gas emissions during composting of sewage sludge. *Energies, 12*, 4782.