

# Additive-Assisted Garden Waste Composting

Alisha A. Tadavi<sup>1</sup>, Dr. M. N. Hedao<sup>2</sup>

<sup>1</sup>PG student, Civil Engineering Department, Government College of Engineering, Amravati (M. S.), 444604,

<sup>2</sup>Adjunct Professor, Civil Engineering Department, Government College of Engineering, Amravati (M. S.), 444604, India.

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**Abstract** - Solid waste disposal is a major challenge in both urban and rural areas worldwide. Effective municipal solid waste (MSW) management requires solutions that are economically viable, technically practical, socially acceptable, legally compliant, and environmentally sustainable. Composting is a sustainable and environmentally friendly method of converting organic waste into a nutrient-rich organic fertilizer through the action of naturally occurring microorganisms. The present study evaluated the effectiveness of different additives in enhancing compost quality, nutrient content, decomposition rate, and microbial activity during garden waste composting. A field-scale composting system was established at Government College of Engineering, Amravati, to assess the practical feasibility and efficiency of additive-assisted composting under real environmental conditions. Various additives, including biochar, rock phosphate, zeolite, and ferrous sulfate, were incorporated into garden waste at different proportions, and their effects on the composting process were investigated. Physicochemical properties were monitored at regular intervals throughout the composting period to evaluate the influence of these additives. The parameters analyzed included pH, temperature, moisture content, EC, organic carbon, nitrogen, phosphorus, potassium, and carbon-to-nitrogen (C:N) ratio. Among the treatments, compost amended with biochar and rock phosphate exhibited superior performance, showing enhanced nutrient enrichment, improved decomposition efficiency, and better compost maturity compared to the control treatment. The results demonstrated that the incorporation of suitable additives can significantly improve the composting process and facilitate the production of high-quality organic fertilizer for sustainable waste management and agricultural applications.

**Key Words:** waste composting, Biochar, zeolite, Rock phosphate, ferrous sulfate, waste management.

## 1. INTRODUCTION

Composting garden waste is a sustainable and cost-effective way to handle organic materials like leaves, grass, and small branches. As urbanization and landscaping

projects continue to increase, the amount of garden waste produced has grown considerably, creating a significant challenge for its proper disposal. [1] Poor management and storage of garden waste cause serious environmental concerns due to the emission of greenhouse gases such as carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O), which contribute to global warming [2]. To overcome these issues, the use of additives in composting has received increasing attention in recent years [3]. In this study, different additives, including biochar, rock phosphate, zeolite, and ferrous sulfate, were evaluated for their effects on garden waste composting efficiency and compost quality [4]. The composting process was carried out for about 30–60 days, depending on the rate of decomposition [7]. During the process, temperature was monitored regularly to observe microbial activity and composting stages [8]. Initially, the compost entered the mesophilic phase at temperatures between 25–40°C, where mesophilic microorganisms rapidly decomposed easily degradable organic matter such as sugars and proteins [9]. Among the additives, biochar produced through biomass pyrolysis was added to improve aeration, porosity, and microbial habitat [5]. Improved aeration enhanced oxygen flow and prevented the formation of anaerobic zones, thereby promoting aerobic microbial growth and accelerating decomposition [10]. Rock phosphate underwent gradual solubilization through microbial activity and the production of organic acids, converting it into plant-available forms [14]. Its addition also improved nutrient availability, fertility, and the agronomic value of the compost [15]. Certain additives further helped in maintaining balanced moisture content by absorbing excess water under wet conditions and releasing it during dry conditions [21]. In addition, pH played an important role in regulating microbial activity and nutrient availability throughout the composting process [22].

## 2. MATERIAL AND METHODOLOGY

### 2.1 Raw Waste and Additives

For the study, garden waste was collected from the campus of Government College of Engineering, Amravati, with the assistance of the garden staff. The collected garden waste mainly consisted of fallen leaves, small branches, twigs, and other biodegradable plant materials. The waste was shredded using a garden waste shredder

machine to reduce particle size and improve decomposition efficiency. Urea was added as a nitrogen source to maintain a suitable C/N ratio and enhance microbial activity during composting. Additives used during experimental work include Biochar, zeolite, rock phosphate and ferrous sulfate at different compositions.

## 2.2 Experimental Setup

The composting bags were designed to ensure efficient decomposition and optimal process performance. High-density polyethylene (HDPE) bags of dimensions 12 ft length, 4 ft width, and 2 ft in depth were used as composting units. These bags were equipped with aeration nets to facilitate adequate oxygen supply and drainage outlets to collect excess leachate, serving as a sustainable and reusable alternative to conventional concrete composting tanks. A 1,2-inch layer of surface soil was placed at the base of each unit to promote microbial activity and provide a natural habitat for microorganisms. Urea was used as a nitrogen-rich source throughout the composting process. Shredded garden waste and urea were layered alternately within the composting beds, while regular watering was carried out to maintain suitable moisture conditions. A total of three HDPE bags were used in triplicate for the experimental study. Each unit was assigned a different additive treatment, including biochar (2%), zeolite (2.5%), rock phosphate (4%), and ferrous sulfate (1%) of the total waste in each bag. A control unit without any additive was also maintained for comparative evaluation. All additives were thoroughly mixed with the composting mass to assess their influence on composting efficiency and final compost quality.

## 2.3 Physico-Chemical Analysis

Physico-chemical analysis is essential for assessing the quality, stability, and maturity of compost throughout the composting process. Temperature was monitored using a 4-in-1 soil tester, while moisture content was determined with an analogue moisture meter. For pH and electrical conductivity (EC) analysis, 10 g of finely ground compost sample was mixed with 100 ml of distilled water and kept for about 30 minutes. After thorough mixing and settling, the pH and EC of the supernatant were measured using a HANNA pH and EC meter. The estimation of key nutrients, including nitrogen (N), phosphorus (P), potassium (K), and organic carbon (OC), was performed at Krishi Vigyan Kendra (KVK), Durgapur, following standard laboratory methods. All measurements were conducted in triplicate, and the mean values were calculated using Microsoft Excel. The results were further presented graphically to illustrate variations in pH, moisture, temperature, electrical conductivity, nitrogen, phosphorus, and potassium during the composting process.

## 2.4 Raw Waste Characterization

The garden waste was collected and processed using a waste shredding machine to obtain uniformly sized particles. The shredded material was then analysed to determine its initial physicochemical properties, including pH, electrical conductivity (EC), moisture content, organic carbon (OC), nitrogen (N), phosphorus (P), potassium (K), and the carbon-to-nitrogen (C:N) ratio. The results of these initial chemical parameters of the raw waste are presented in the table 1.

**Table 1. Chemical characterization of dry raw garden waste**

Sr.No.	Chemical parameters	Initial Value
1	Moisture	40 %
2	Ph	5.85
3	Electric conductivity (EC)	481 $\mu$ S/cm
4	Nitrogen (N)	0.70 %
5	Phosphorus (P)	0.61 %
6	Potassium (P)	0.68 %
7	Organic carbon (OC)	30.12 %
8	C/N Ratio	43.03 %

The shredded garden waste was subjected to decomposition in the composting unit for a period of 60 days, during which periodic analyses of waste characteristics were carried out. The results obtained from these observations are presented in the Results and Discussion section.

## 3. RESULT AND DISCUSSION

### 3.1 Effects of Additives on Change in pH during Composting

The pH value denotes the loss of nitrogen content. A pH between 6-7.5 is good for bacterial growth, while a pH between 5.5-8 is suitable for fungal growth, and when pH is greater than 7, the nitrogen volatilizes in the form of ammonia.[14]. All the treatments had pH values in the range. Among the additives, the highest final pH value was recorded in rock phosphate 4% (7.17) followed by 1% ferrous sulfate (6.92), 2% zeolite (6.63) and control unit (6.59), 2.5% biochar (6.52). The pH values obtained in all the treatments were near neutral, indicating stabilization and maturity of compost. pH Decrease might occur due to mineralization of nitrogen and phosphorus to nitrites/nitrates and orthophosphates and bioconversion of organic matter to intermediate species of organic acids [15]. The variation in pH during composting is shown in Figure 1.

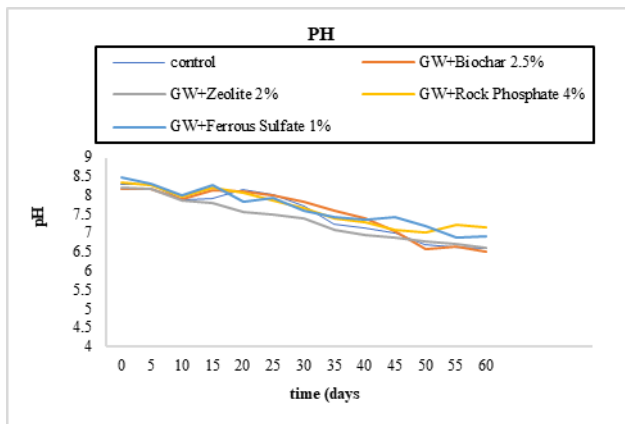


Figure 1. Change in pH during Composting Treatment

### 3.2 Effects of Additives on Change in Moisture Content during Composting

The optimum moisture content is essential for composting. Maximum moisture content was observed in biochar 2.5% (68.06) followed by zeolite 2% (60.67), rock phosphate 4% (58.76), control unit (54.10). Moisture level, in optimal compost, the moisture level should be around 50-60%. Insufficient moisture hampers the activity of microorganisms, which slows down the process, while excessive moisture results in anaerobic conditions that can produce unpleasant odors and hinder matter breakdown.[15]. The variation in moisture content during composting is shown in Figure 2.

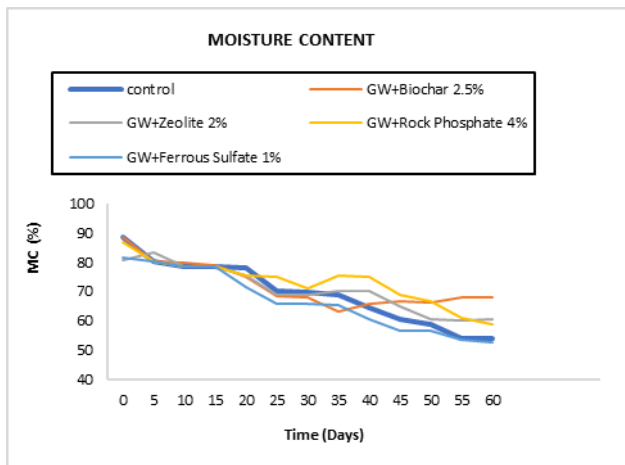


Figure 2. Change in Moisture Content during Composting Treatment

### 3.3 Effects of Additives on Change in Temperature during Composting

The temperature profile is a key parameter, because temperature play important role in the destruction of pathogens. [16,17]. initially the temperature rises up to in

all treatments, this is due to microbial activity and decomposition of readily biodegradable substrates resulting in heat generation. After this phase, the temperature gradually decreased or stabilized due to the consumption of readily degradable organic substrates, reducing microbial respiration and heat production. The highest temperature was recorded in biochar 2.5% (32.66), followed by rock phosphate 4% (30.91), zeolite 2% (30.90), ferrous sulfate 1% (30.47) and the control unit (30.60). However, the addition of biochar, zeolite, jaggery, and polyethylene glycol to compost prepared from animal manure, food waste, and green waste resulted in increased temperatures. Similar temperature patterns have also been reported with the use of biological and organic additives during composting [18]. Change in temperature during composting is shown in Figure 3.

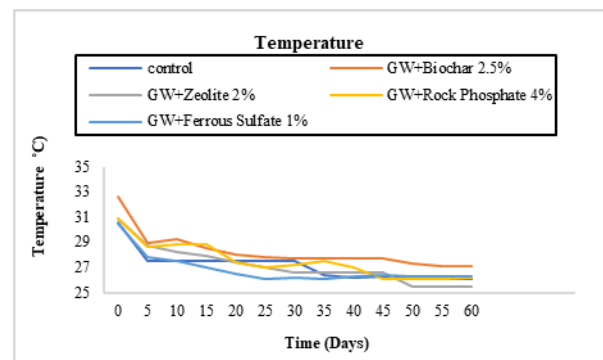


Figure 3. Change in Temperature during Composting Treatment

### 3.4 Effects of Additives on Change in Electrical Conductivity (EC) during Composting

Electrical conductivity (EC) increased gradually in all treatments during the initial stages of composting. The EC values recorded in the mature compost remained below 10 dS/m. The reduction in EC during the final stage of composting may be attributed to the loss of ammonia through volatilization and the precipitation of soluble mineral salts, resulting in a lower concentration of dissolved ions.[19,20], An EC value of less than 4 dS/m is widely regarded as the recommended limit for compost intended for agricultural use and soil amendment.[21,22]At the end of composting, the highest EC was observed in GW + biochar 2.5% (1409), followed by the GW+ rock phosphate 4% (1172), GW + ferrous sulfate 1% (975.9), GW + zeolite 2% (902.4) and the control unit (876.9). Change in electrical conductivity during composting is shown in Figure 4.

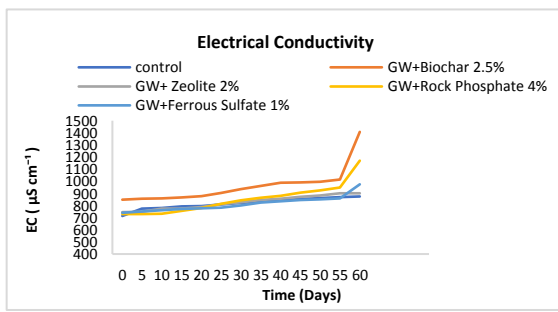


Figure 4. Change in Electrical Conductivity during Composting Treatment

### 3.5 Effects of Additives on Change in Nitrogen during Composting

Nitrogen is a vital nutrient for plant growth and a major component of chlorophyll, which gives plants their green colour. Compost generally contains sufficient nitrogen to support healthy plant development.[23]. Total nitrogen values showed a progressive trend in the composting period. The maximum value of nitrogen was observed in 2.5% biochar (1.57%) among all the treatments. The increase in total nitrogen content was attributed to the decomposition of organic matter and the loss of carbon as CO<sub>2</sub> during composting. Additionally, the activity of nitrogen-fixing bacteria contributed to the enrichment of nitrogen in the compost. [24]. Change in Nitrogen during composting is shown in Figure 5

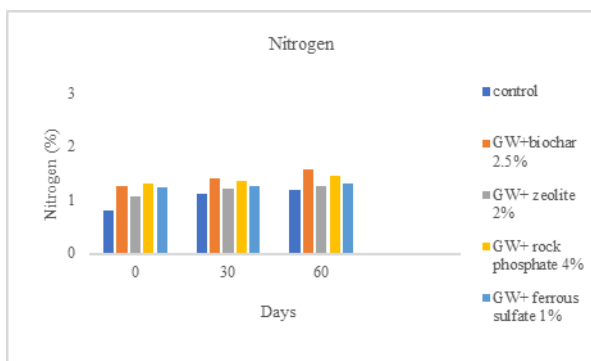


Figure 5. Change in Nitrogen during Composting Treatment

### 3.6 Effects of Additives on Change in Phosphorus (P) During Composting

The gradual increase of phosphorous was attributed to the reduction in dry mass caused by the decomposition of organic matter and the emission of gases such as CO<sub>2</sub>, NH<sub>3</sub>, and H<sub>2</sub>S during the composting process.[25] Compost prepared with 2.5 % of biochar showed the highest phosphorous content (2.50) among all the treatments.

Change in Phosphorus during vermicomposting is shown in Figure 6.

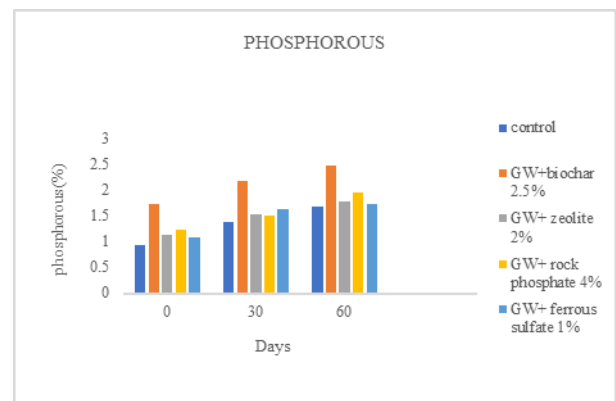


Figure 6. Change in Phosphorous during Composting Treatment

### 3.7 Effects of Additives on Change in Potassium (K) during Composting

Potassium is an essential macronutrient required for various physiological and biochemical processes in plants. The lower potassium content in compost may be attributed to leaching losses, as potassium is highly soluble in water. The use of adequate aeration and fibrous bulking materials can help reduce nutrient loss and improve potassium retention.[26] Compost prepared with 2.5% of biochar showed (1.76) the highest potassium content among all the treatments. Change in Phosphorus during vermicomposting is shown in Figure 7.

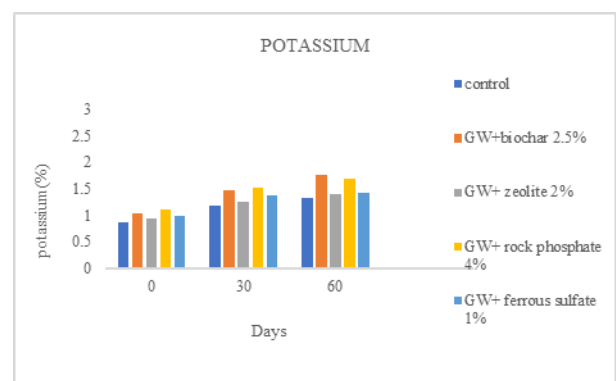


Figure 7. Change in Potassium during Composting Treatment

### 3.8 Effects of Additives on Change in C/N Ratio during Composting

The organic carbon content of all treatments of biochar, zeolite, rock phosphate and ferrous sulfate assisted composting in the ratio of 25–35 % was within the acceptable limit of mature and good quality, which is also

suggested by a previous study [27]. In most composting systems, a C/N ratio of about 30:1 is regarded as ideal for microbial growth and effective carbon oxidation. The C/N ratio is widely used as an indicator of compost stability and maturity [28]. A C/N ratio near 12 is often considered characteristic of fully matured compost, while a final C/N ratio of less than 20 is generally accepted as an indicator of satisfactory compost maturity [29].

#### 4 CONCLUSION

It can be concluded that composting is an environmentally friendly and practical method for managing garden waste. The inclusion of additives accelerates the decomposition of waste and leads to improved compost quality. Additives facilitate the rapid breakdown of organic materials. The compost produced from units using additives was found to be more nutrient-dense than that from the control unit. A C/N ratio of 20 or below indicates that the compost is at a mature stage; therefore, compost derived from GW with 2.5% biochar is considered well-matured, exhibiting the lowest C/N ratio along with the highest levels of nitrogen, phosphorus, and potassium compared to other additives. Compost generated from biochar-treated garden waste was observed to be more nutrient-rich and possess advantageous chemical properties.

#### REFERENCES

- 1) Khalib SN, Zakarya IA, Izhar TN. Composting of garden waste using indigenous microorganisms (IMO) as organic additive. *International Journal of Integrated Engineering*. 2018;10(9).
- 2) Noor RS, Shah AN, Tahir MB, Umair M, Nawaz M, Ali A, Ercisli S, Abdelsalam NR, Ali HM, Yang SH, Ullah S. Recent trends and advances in additive-mediated composting technology for agricultural waste resources: A comprehensive review. *ACS omega*. 2024 Feb 16;9(8):8632-53.
- 3) Mankhair RV, Borkar RP. Additives Aided Rapid Composting Treatment of Garden Waste. *International Research Journal of Engineering and Technology (IRJET)*. 2020;7(08):15-20.
- 4) Barthod J, Rumpel C, Dignac MF. Composting with additives to improve organic amendments. A review: J. Barthod et al. *Agronomy for Sustainable Development*. 2018 Apr;38(2):17.
- 5) Yin Z, Zhang L, Li R. Effects of additives on physical, chemical, and microbiological properties during green waste composting. *Bioresource Technology*. 2021 Nov 1;340:125719.
- 6) Zhang L, WANG H, WANG W, Wang X, Li J, Li L, GUO W, Liu S, Wang H, LU Y, Ma L. Accelerating carbon conversion in garden waste composting with food waste-expanding microbial inoculants. *Chinese Journal of Eco-Agriculture*. 2022 Nov 25;31(5):785-95.
- 7) Rastogi M, Nandal M, Khosla B. Microbes as vital additives for solid waste composting. *Heliyon*. 2020 Feb 1;6(2).
- 8) Yao X, Wang X, Zheng S, Zhao H, Ju J, Wang C. Research on composting of garden waste and its application in cultivation substrates. *Sustainability*. 2024 Sep 21;16(18):8216.
- 9) Amarasinghe SR. Effects of Different Additives on the Quality of Composts Produced from Ordinary Garden Leaf Litter. *Tropical Agricultural Research and Extension*. 2022 Apr 7;25(1).
- 10) Boutasknit A, Anli M, Lahlali R, Meddich A. Effect of organic waste and inorganic additives on organic matter transformation and mineral availability in composting green waste. *Phyton-International Journal of Experimental Botany*. 2024 Sep 1;93(9):2227-49.
- 11) Zhang B, Fan F, Guo C, Yu M, Zhao M, Song Y, Li Y. Evaluation of maturity and odor emissions in the process of combined composting of kitchen waste and garden waste. *Applied Sciences*. 2021 Jun 14;11(12):5500.
- 12) Najib NN, Nugroho HY, Isnain W, Saad M. Effect of size and additives on the decomposition process and nutrient content of urban organic waste compost. In IOP conference series: Earth and environmental science 2023 May 1 (Vol. 1180, No. 1, p. 012043). IOP Publishing.
- 13) Malakahmad A, Idrus NB, Abualqumboz MS, Yavari S, Kutty SR. In-vessel co-composting of yard waste and food waste: an approach for sustainable waste management in Cameron Highlands, Malaysia. *International Journal of*

- Recycling of Organic Waste in Agriculture. 2017 Jun;6(2):149-57.
- 14) Pragati Kanaujiya , Devendra Dohare, 2020, Study of Composting for Municipal Organic Waste A Review, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) Volume 09, Issue 11 (November 2020)
- 15) Amruta Chandrakant Nimbalkar, Samiksha Sunil Pisal, et.al., "Bioconversion of Garbage: Garden Waste (GW); Kitchen Waste (KW) and Combination of Both Garbage: Garden Waste and Kitchen (GW +KW) into Vermicompost through the use of earthworm, *Eisenia fetida* (L)",(2018), International Journal of Scientific Research in Chemistry (IJSRCH) | Online ISSN: 2456-8457
- 16) Gea T, Barrena R, Artola A, Sánchez A (2007) Optimal bulking agent particle size and usage for heat retention and disinfection in domestic wastewater sludge composting. *Waste Manag* 27:1108–1116.
- 17) Haug RT (1993) The practical handbook of compost engineering. CRC Press, Boca Raton.
- 18) Manu MK, Kumar R, Garg A (2017) Performance assessment of improved composting system for food waste with varying aeration and use of microbial inoculum. *Bioresour Technol* 234:167–177.
- 19) Raj D, Antil R. Evaluation of maturity and stability parameters ofcomposts prepared from agro-industrial wastes. *Bioresour Technol*.2011;102:2868–73.
- 20) Masresha M, Henok K, Lalit I, Stefaan D. Evaluation of compost qualityfrom municipal solid waste integrated with organic additive in Mizan-Aman town, Southwest, Ethiopia. *BMC Chem*. 2021;15:43. [https:// doi. org/10. 1186/ s13065- 021- 00770-](https://doi.org/10.1186/s13065-021-00770-)
- 21) Mukhtar Z, Justisia B, Setyowati N. Quality enhancement of humdtropical soils after application of water hyacinth (*Eichornia crassipes*)compost. *J Agric Technol*. 2016;12:1211
- 22) John M. Production of organic compost from water hyacinth (*Eichhorniacrassipes*) in the Lake Victoria Basin: a lake Victoria research initiative(VicRes). *Res Rev J Agric Allied Sci*. 2016;5:55–62.
- 23) Khater, E. Some physical and chemical properties of compost. *Int. J. Waste Resour*. **2015**, 5, 1–5. [CrossRef]
- 24) Garcia C, Hernandez T, Costa F, Ayuso M (1992) Evaluation of the maturity of municipal waste compost using simple chemical parameters. *Commun Soil Sci Plant Anal* 23:15011512.doi:10.1080/001036292093683
- 25) Bustamante M, Paredes C, Morales J, Mayoral A, Moral R (2009)Study of the composting process of winery and distillery wastesusing multivariate techniques.*BioresourTechnol*100:47664772.doi:10.1016/j.biortech.2009.04.033
- 26) Iyengar SR, Bhav PP (2006) In-vessel composting of household wastes. *Waste Manag* 26(10):1070–1080.<https://doi.org/10.1016/j.wasman.2005.06.011>
- 27) Torres-Climent,A.;MartinMata,J.;Marhuenda-Egea,F.C.;Moral,R.;Barber,X.;Murcia,M.D.P.;Paredes,C.Compostingofthesolidphaseofdigestatefrombiogasproduction:Optimizationofthemoisture,C/NRatio,andpHConditions.*Commun.SoilSci.PlantAnal*.2015,46,197207.[CrossRef]
- 28) Mahapatra,S.;Ali,M.H.;Samal,K.AssessmentofcompostmaturityStabilityindicesandrecentdevelopments ofcompostingbin. *EnergyNexus*2022,6,100062. [CrossRef]
- 29) Azis, F.A.; Choo, M.; Suhaimi, H.; Abas, P.E. The Effect of Initial Carbon to Nitrogen Ratio on Kitchen Waste Composting Maturity. *Sustainability* 2023, 15, 6191. <https://doi.org/10.3390/su15076191>