

Recovery of Biodegradable Waste through Composting: Monitoring of Technical Parameters in a Windrow in Guinea

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How to cite this paper: Balde, M.Y., Diallo, M.A.II, Bah, T.B., Bah, H., Diallo, M.O.2, Diallo, D.F., Camara, M.B. and Barry, H. (2026) Recovery of Biodegradable Waste through Composting: Monitoring of Technical Parameters in a Windrow in Guinea. *Agricultural Sciences*, 17, 1101-1114.

<https://doi.org/10.4236/as.2026.1710062>

Received: September 8, 2026

Accepted: October 17, 2026

Published: October 20, 2026

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Abstract

Composting is one of the most effective methods for recycling biodegradable waste, particularly in developing countries where municipal solid waste management poses a major environmental challenge. This study focuses on the technical monitoring of an open windrow comprising 4 metric tons of sorted biodegradable waste, established on a 36 m² platform in Conakry (Guinea) over a 69-day cycle. The initial mixture was prepared on a fresh-mass basis by alternating layers of carbon-rich feedstocks (1818 kg; sawdust, dry leaves, cardboard, paper) and nitrogen-rich feedstocks (2182 kg; cow manure, fruit waste, organic household waste, fresh leaves) targeted to achieve an optimal recipe for biological stabilization. Three mechanical turnings were carried out on days 15, 28 and 48 to ensure oxygenation and homogenization of the decomposing mass. Daily monitoring focused on ambient temperature and windrow temperature, the amount of water applied and the moisture content. Four successive stages of decomposition were observed: mesophilic, advanced mesophilic, thermophilic and maturation. Maximum temperatures exceeded 55°C at the windrow core during the thermophilic stage (maintained above 55°C for 5 consecutive days), creating thermal conditions compatible with the sanitization requirements of international composting standards. The maturation phase (D48-D69) was characterized by the windrow temperature converging towards ambient temperature and a decrease in moisture content. Following shredding and sieving (D77-D80), 1500 kg of fine compost was obtained, representing a yield of 37.5%. The correlations between temperature,

the amount of water applied and moisture content reveal an interdependent dynamic reflecting microbial activity and heat exchange within the windrow.

Keywords

Composting, Windrow, Biodegradable Waste, Temperature, Moisture, C/N Ratio, Guinea, Organic Recovery

1. Introduction

The management of municipal solid waste is a growing environmental and public health challenge in cities across sub-Saharan Africa, where collection rates remain inadequate and biodegradable organic matter often accounts for more than 60% of the total waste stream [1] [2]. In Guinea, the capital, Conakry, faces an estimated daily waste production of 1500 metric tons (1500 t), the majority of which is not managed in a sustainable manner [3]. In this context, composting emerges as a technology that is both accessible and effective, enabling organic waste to be transformed into fertilizing soil amendments whilst reducing the greenhouse gas emissions associated with landfill or uncontrolled incineration.

Composting is an aerobic process of controlled biodegradation during which micro-organisms (bacteria, fungi, actinomycetes) break down organic matter in the presence of oxygen and water, and under favorable thermal conditions [4] [5] (Haug, 1993). This process is characterized by a succession of thermal phases: mesophilic, thermophilic and maturation, the duration and intensity of which depend on the nature of the raw materials, the carbon-to-nitrogen (C/N) ratio, moisture content, particle size and the frequency of turning [6] .

The C/N ratio is one of the most critical parameters for the equilibrium of the process. A ratio that is too high (>40) slows down decomposition due to nitrogen deficiency, whilst a ratio that is too low (<20) causes nitrogen losses in the form of ammonia and generates undesirable odors [7]. The optimal value generally recommended is between 25 and 35 [8] [9]. In this study, a ratio of 25/30 was adopted, comprising 1818 kg of carbon-rich fractions and 2182 kg of nitrogen-rich fractions, making a total of 4 metric tons.

Moisture management is another critical factor: too low a moisture content (<40%) inhibits microbial activity, whilst excessive moisture (>65%) leads to anaerobic conditions and the production of methane and leachate [10]. Temperature, meanwhile, is both an indicator of microbial activity and a factor in the sanitization of compost: temperatures above 55°C for several consecutive days destroy pathogens, plant pathogens and weed seeds [11] [12].

Although composting has been practiced empirically for centuries, the rigorous implementation of technical monitoring (temperature, moisture, water additions) remains poorly documented in West African contexts, particularly in Guinea. This study aims to partially address this gap by presenting a detailed 69-day monitoring of a low-tech compost heap, which can be implemented at community or

semi-industrial scale. The correlations between temperature, the amount of water applied and the moisture content of the heap are analyzed with a view to identifying practical recommendations for optimizing the process.

2. Materials and Methods

2.1. Experimental Site and Composting Platform

The experiment was carried out on a 36 m² (6 m × 6 m) composting platform set up in a semi-urban area in Conakry, Guinea. The surface was prepared by compacting it and giving it a slight slope to facilitate the drainage of leachate. A protective tarpaulin was used in the event of heavy rain to prevent excess moisture. The site was surrounded by a natural ventilation system to ensure a sufficient supply of oxygen during the active stages of decomposition.

2.2. Feedstock Composition and Heap Formulation

The initial composting heap was formulated using a total wet mass of 4000 kg of raw organic materials. To promote balanced aeration and degradation, feedstocks were categorized into two main functional groups: Nitrogen-rich waste (Total 1 = 2182 kg wet mass) and Carbon-rich waste (Total 2 = 1818 kg wet mass).

The heap was constructed by systematically stacking (**Figure 1**) these raw materials in alternating layers (nitrogen-rich materials alternating with carbon-rich materials), with each individual layer built to a uniform thickness of approximately 25 cm until the total mass of 4000 kg was fully incorporated. These raw materials were collected from specific local origins, namely households (kitchen scraps), fruit and vegetable markets (fruit waste and fresh leaves), slaughterhouses (animal manure), carpentry workshops (sawdust), an IT service center (cardboard), and agricultural/local sources (dry leaves, straw). The detailed breakdown of the 10 raw inputs, their categorization, and their respective mass contributions are summarized in **Table 1**.

Table 1. Proportions and breakdown of raw organic feedstocks in the initial 4000 kg composting mixture.

N°	Type	Type of waste	Quantity (kg)	
1	Nitrogen-rich waste	Animal waste	Cow manure	1464
2		Plant waste	Fruit (oranges, bananas, etc.)	221
3		Household waste	Kitchen scraps	191
4		Plant waste	Fresh leaves	306
Total 1				2182
5	Carbon-rich waste	Plant waste	Dry leaves	267
6		Wood waste	Sawdust	310
7		Plant waste	Dry leaves	473
8		Wood waste	Sawdust	585
9		Wood waste	Cardboard	65.5
10		Wood waste	Dry straw	117.5
Total 2				1818
Grand total				4000



Figure 1. Image of the windrow.

2.3. Composting Management and Turning

Three mechanical turnings, using a fork and a spade, were carried out on days 15 (R1), 28 (R2) and 48 (R3) of the experiment, respectively. The aims of these turnings were to homogenize the heap, re-oxygenate the decomposing mass, redistribute moisture and even out temperature gradients. Between turnings, supplementary watering was carried out as soon as the visual (pellet test) or measured moisture content indicated that the surface or outer layers were drying out.

2.4. Measured Parameters and Equipment

Daily monitoring covered four variables: i) ambient air temperature, ii) windrow temperature, iii) windrow moisture content, and iv) the volume of water applied. Graduated watering cans delivered the water, and daily records logged the applied volume.

- ✓ Sensor positions and installation. Measurements covered three positions in the 1.2 m high trapezoidal windrow, with depths taken perpendicular to its outer surface: (a) core zone, at the center of the windrow, 60 - 70 cm deep; (b) flank zone, 20 - 30 cm deep; (c) mid-slope zone, halfway up the slope, 10 - 20 cm deep. At each position, one moisture sensor and one thermocouple probe sat

side by side, so that both variables refer to the same location. Sensors and probes went into pre-dug pockets, came out before each turning (days 15, 28 and 48), and returned to the same positions afterwards.

- ✓ **Moisture measurement.** Three wireless soil moisture sensors (model WH51, Ecowitt), linked to an HP1000SE PRO monitoring console, recorded moisture. These capacitive sensors respond to the dielectric permittivity of the matrix and output a moisture index between 0 and 100% (resolution 1%) under the manufacturer's default settings. The reported values therefore represent a relative moisture index (%), not the relative humidity of the air, nor gravimetric or volumetric water content, and no oven-drying check validated them. They served to follow the temporal evolution of moisture in the windrow and to compare it with temperature and water additions, not as absolute water contents.
- ✓ **Temperature measurement.** A 4-channel K-type thermocouple data logger (model 88598, AZ Instrument Corp., Taiwan region), fitted with four bead-type K thermocouple probes on 4m cables, measured temperature. According to the manufacturer, the logger has a resolution of 0.1 °C and an accuracy of $\pm (0.3\% \text{ of reading} + 1^\circ\text{C})$, *i.e.*, $\pm 1.2^\circ\text{C}$ at 55 °C, at an ambient temperature of 18 °C - 28 °C. This figure applies to the logger alone; the tolerance of the probes adds to it. The logger stayed sheltered from rain and direct sun. Three probes covered the positions described above, and the fourth measured ambient air temperature in the shade, 3m from the windrow, under a radiation shield.
- ✓ **Observation time and daily values.** Manual readings from the console and logger displays took place once a day at 08:00, before the daily watering. This fixed time standardizes conditions and precedes the daytime rise in ambient temperature; ambient temperature therefore corresponds to the 08:00 value, not to a daily mean. The unweighted arithmetic mean of the three simultaneous readings gave a single daily value of windrow temperature and moisture (see Equation (1) and Equation (2)):

$$T_{\text{daily}} = \frac{T_{\text{core}} + T_{\text{flank}} + T_{\text{surface}}}{3} \quad (1)$$

$$\text{Moisture}_{\text{daily}} = \frac{\text{Moisture}_{\text{core}} + \text{Moisture}_{\text{flank}} + \text{Moisture}_{\text{surface}}}{3} \quad (2)$$

Zone-specific values remained available to report the duration above 55 °C for each zone. Core temperature served as the basis for the thermophilic criterion ($\geq 55^\circ\text{C}$) and for the correlation analysis (Section 2.7).

Other equipment. A scale (capacity 50 kg) determined feedstock and product masses. Other equipment included shovels, pitchforks, rakes, wheelbarrows, wire sieves (10-mm and 20-mm mesh), waterproof tarps, and personal protective equipment.

2.5. Decomposition Phases and Maturity Indicators

Four decomposition phases were identified: a) mesophilic phase (D1-D14), b) advanced mesophilic phase (D15-D27), c) thermophilic phase (D28-D47) and d)

maturation phase (D48-D69). Compost maturity was assessed on the basis of a combination of criteria: stabilization of temperatures at ambient levels, a uniform dark brown color, an earthy odor, the absence of perceptible heat at the center of the windrow, and germination tray tests.

2.6. Spreading, Shredding, and Sieving

At the end of the maturation phase, the heap was spread out between days 70 and 76 for final aeration and passive sun-drying, reducing the final compost moisture content to approximately 32% - 35%. Shredding and sieving (10-mm mesh) were conducted between days 77 and 80. A total of 1,500 kg of refined compost (<10 mm) was recovered on a fresh (wet) mass basis, representing a wet-mass yield of 37.5% relative to the 4000 kg initial wet feedstock. The coarse oversize fraction (>10 mm, consisting mainly of non-degraded woody fragments and inert residues) accounted for approximately 120 kg; this organic fraction was set aside to serve as recycled bulking agent (inoculum) for subsequent composting windrows. Cumulative water additions throughout the 69-day process amounted to approximately 7144 liters, compensating for evaporative losses during the thermophilic stage.

2.7. Statistical Analysis

Daily monitoring data were collected and processed over the entire 69-day composting period ($n = 69$ valid daily observations, with no missing data). Correlations between windrow core temperature, daily water volume applied, and the windrow relative moisture index were determined using Pearson's correlation coefficient (r) following the statistical framework outlined by El Boudihi (2024) [13], according to Equation (3):

$$r = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2} \sqrt{\sum_{i=1}^n (y_i - \bar{y})^2}} \quad (3)$$

where:

- x_i and y_i = observed values of the two variables (e.g., windrow temperature and moisture content) on day i ;
- $\bar{x}$ and $\bar{y}$ = sample means of the respective variables;
- n = total number of valid observation days ($n = 69$);
- r = Pearson's correlation coefficient ranging from -1 to $+1$.

For each correlation coefficient, two-tailed p -values and 95% confidence intervals (95%CI) were calculated to assess statistical significance and estimation uncertainty. Furthermore, to account for potential temporal autocorrelation (serial dependence) in daily time-series data, correlation analyses were performed both across the four identified composting phases—Mesophilic (D1-D14), Advanced Mesophilic (D15-D27), Thermophilic (D28-D48), and Maturation (D49-D69); and on first-differenced daily values ($\Delta X_t = X_t - X_{t-1}$). Data compilation and statistical calculations were executed using Microsoft Excel.

3. Results and Discussion

3.1. Temperature Trends

The detailed daily changes in ambient and windrow temperatures during the four stages of decomposition are presented in **Figure 2**, while **Figure 3** illustrates the overall trend over the 69 days, incorporating the three turnings (R1, R2, R3).

The curve highlights the successive temperature peaks associated with the reversals, which are characteristic of an active aerobic process, and the gradual decline towards ambient temperature during the maturation phase.

The initial mesophilic phase (D1-D14) is characterized by a rapid rise in temperature linked to the activity of mesophilic microorganisms breaking down the most labile substrates (sugars, amino acids, soluble proteins). The windrow temperature exceeded ambient temperature within the first 48 hours, confirming the onset of the fermentation process [12].

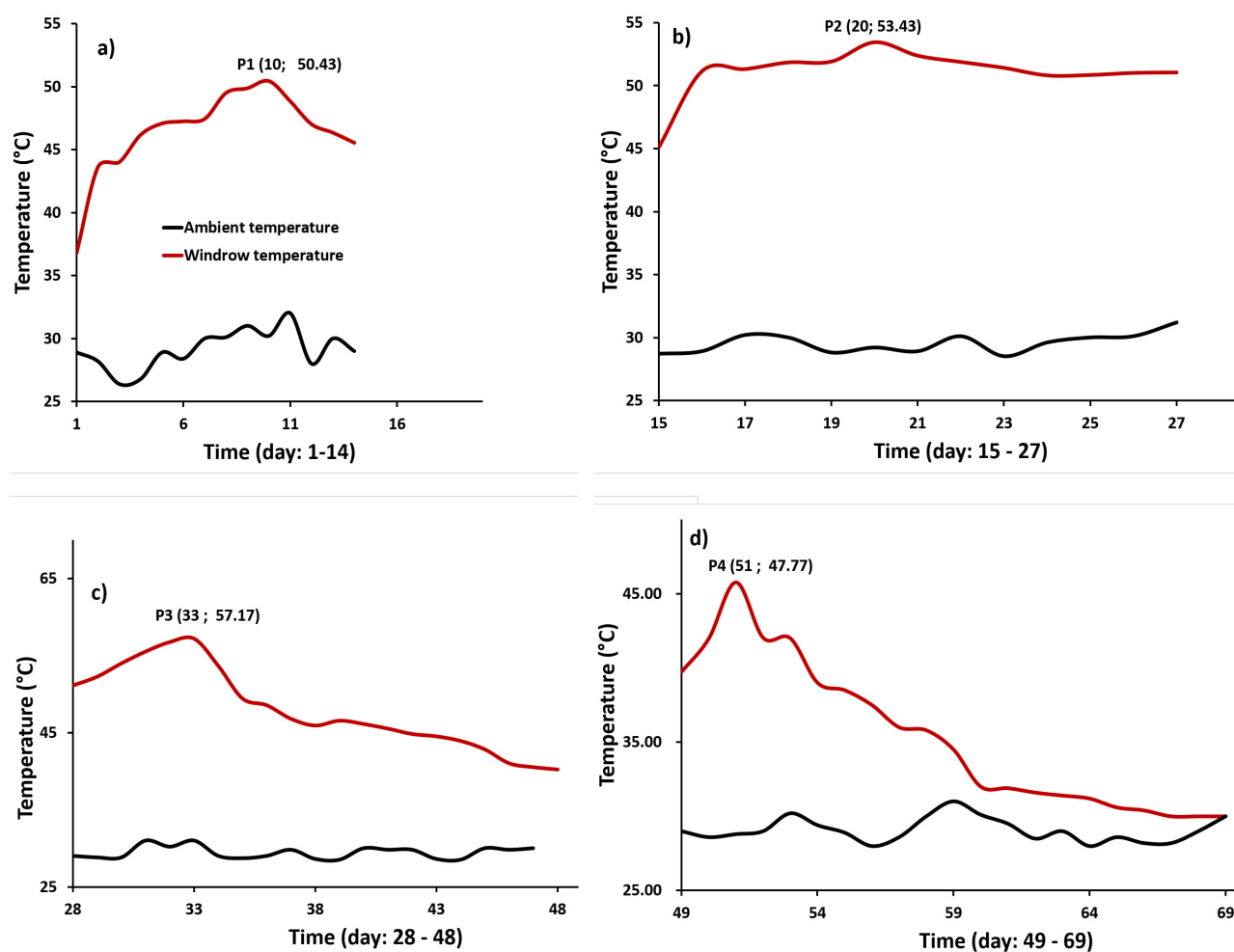
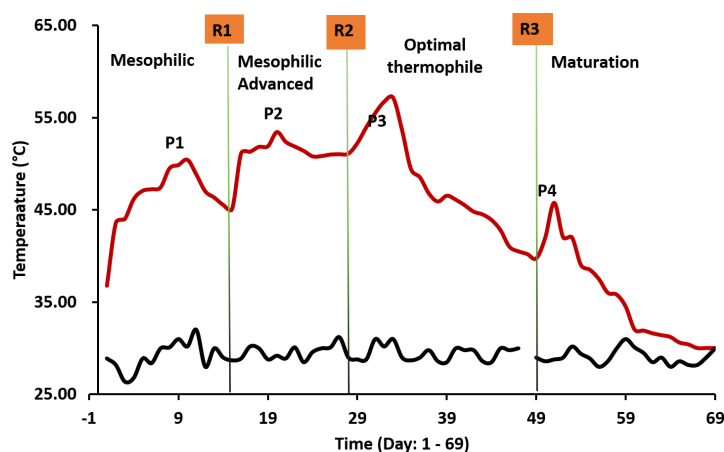


Figure 2. Detailed monitoring of windrow temperature (red) and ambient temperature (black) according to the stages of decomposition. (a) Mesophilic stage (Days 1 - 14): gradual rise to 38°C - 45°C; (b) Advanced mesophilic phase (D15-D27): following the first turning (T1), temperature maintained between 45°C and 55°C; (c) Thermophilic phase (D28-D48): P3 peak exceeding 55°C in the core zone after R2, establishing thermal conditions compatible with mass sanitization; (d) Maturation phase (D49-D69): gradual convergence of the windrow temperature towards ambient temperature after R3, signaling the completion of active decomposition.



R1, R2, R3: turning operations on days 15, 28 and 49 respectively. P1, P2, P3, P4: maximum temperatures recorded for each phase.

Figure 3. Overall temperature trend curve for the windrow over 69 days.

The thermophilic phase (D28-D47), which began after the second turning (R2), was the most intense in terms of temperature. Temperatures exceeding 55°C, maintained for several consecutive days, meet the hygienist criteria defined by European standards (> 55°C for ≥ 3 days in an open, turned system) and the WHO (World Health Organization) recommendations [9] [11]. This phase also corresponds to the degradation of recalcitrant fractions such as cellulose, hemicellulose and part of the lignin [10].

Each turning operation triggered a thermal revival (peaks P2, P3) by reintroducing oxygen into the mass, stimulating aerobic microbial populations and redistributing areas still rich in degradable organic matter. This phenomenon, which is well documented in the literature [7] [8], confirms the effectiveness of the turning at increasing intervals adopted in this protocol.

During the maturation phase (Days 48-69), the almost complete convergence of the windrow temperature towards ambient temperature after Day 60—observed over the final 10 days of monitoring—served as the main operational indicator of compost maturity. This observation is consistent with the work of Sow *et al.* and that of Awasthi *et al.*, as well as [1], which place the end of active decomposition at thermal equilibrium with the environment.

The thermophilic phase (D28-D48), initiated after the second turning (R2), represented the most thermally active period of the process. In the core zone, temperatures exceeded 55°C on Day 30 and remained above this threshold for 5 consecutive days (peaking at 57.17°C on Day 33, P3), successfully fulfilling standard sanitization criteria (e.g., European standards and WHO guidelines requiring >55°C for at least 3 consecutive days in turned windrow systems) [9] [11]. In the intermediate flank zone, temperatures peaked at 52.4°C, remaining between 48°C and 52°C during this peak window, whereas the peripheral surface layer remained cooler (peaking at 41.8°C) due to continuous convective heat dissipation to the ambient air.

Although direct microbiological assays (e.g., enumeration of *Salmonella* spp. or fecal coliforms) were not performed, the systematic mechanical turnings (R1, R2,

R3) ensured adequate material exchange between the cooler outer layers and the thermophilic core. Consequently, the thermal profiles observed throughout the windrow indicate conditions highly compatible with pathogen reduction and mass sanitization. **Table 2** summarizes the key physicochemical parameters characterizing each phase of the composting process.

Table 2. Summary of key parameters by composting stage.

Phase	Days	T°C windrow (max)	Turnaround	Water added (L)	Moisture content (%)
Mesophilic	D1-D14	≈38°C - 45°C	-	Variable	50 - 60
Mesophilic advanced	D15-D27	≈45°C - 55°C	R1 (J15)	Variable	45 - 55
Thermophilic	D28-D48	>55°C	R2 (J28)	Reduced	40 - 50
Maturation	D49-D69	≈T° ambient	R3 (J49)	Minimum	35 - 45

3.2. Moisture Content and Water Additions

The volume of water supplied to the windrow (**Figure 4**) followed a dynamic closely governed by temperature variations.

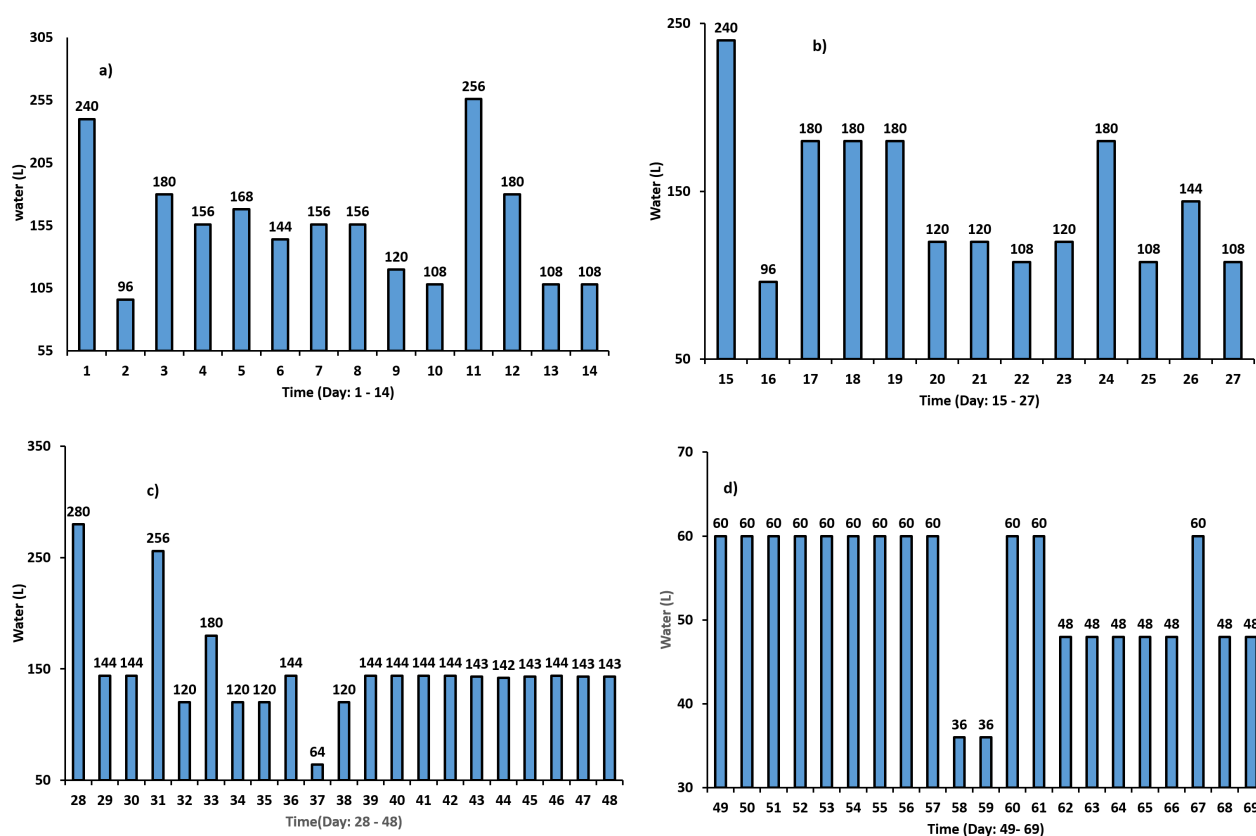


Figure 4. Amount of water added (in liters) to the windrow according to decomposition stages: (a) Mesophilic stage: frequent, calibrated water additions to compensate for evaporation driven by temperature rise and surface moisture loss; (b) Advanced mesophilic stage: maintenance of targeted moisture levels to support active bacterial colonization; (c) Thermophilic stage: progressive reduction in water application as evaporation rates slowed toward the end of the phase; (d) Maturation stage: negligible or no water addition, as residual microbial activity ceased to generate significant evaporation. Irrigation peaks coincided with mechanical turning days (R1, R2, R3), when redistributing internal moisture was essential.

Water requirements peaked during the mesophilic and early thermophilic phases, driven by intense microbial heat generation and convective moisture loss. Conversely, during maturation, water inputs became minimal as metabolic activity dropped sharply. This behavior illustrates the “thermal-hydric coupling” conceptualized by Huang *et al.* [10]: elevated temperatures accelerate evaporation, which—without compensation; leads to matrix desiccation and halts biodegradation. Conversely, excessive watering restricts windrow porosity, limiting oxygen diffusion and inducing anaerobic micro-pockets [7].

Mechanical turning events were central to moisture management: on each turning day (R1, R2, and R3), targeted irrigation was systematically applied to compensate for dry outer crusts, homogenize internal moisture, and revitalize microbial metabolism (Figure 4). Consequently, the overall windrow moisture content was successfully maintained within the optimal range of 40% - 60% throughout the process (Figure 5). The variation in windrow moisture content (%) throughout the composting phases is shown in Figure 5.

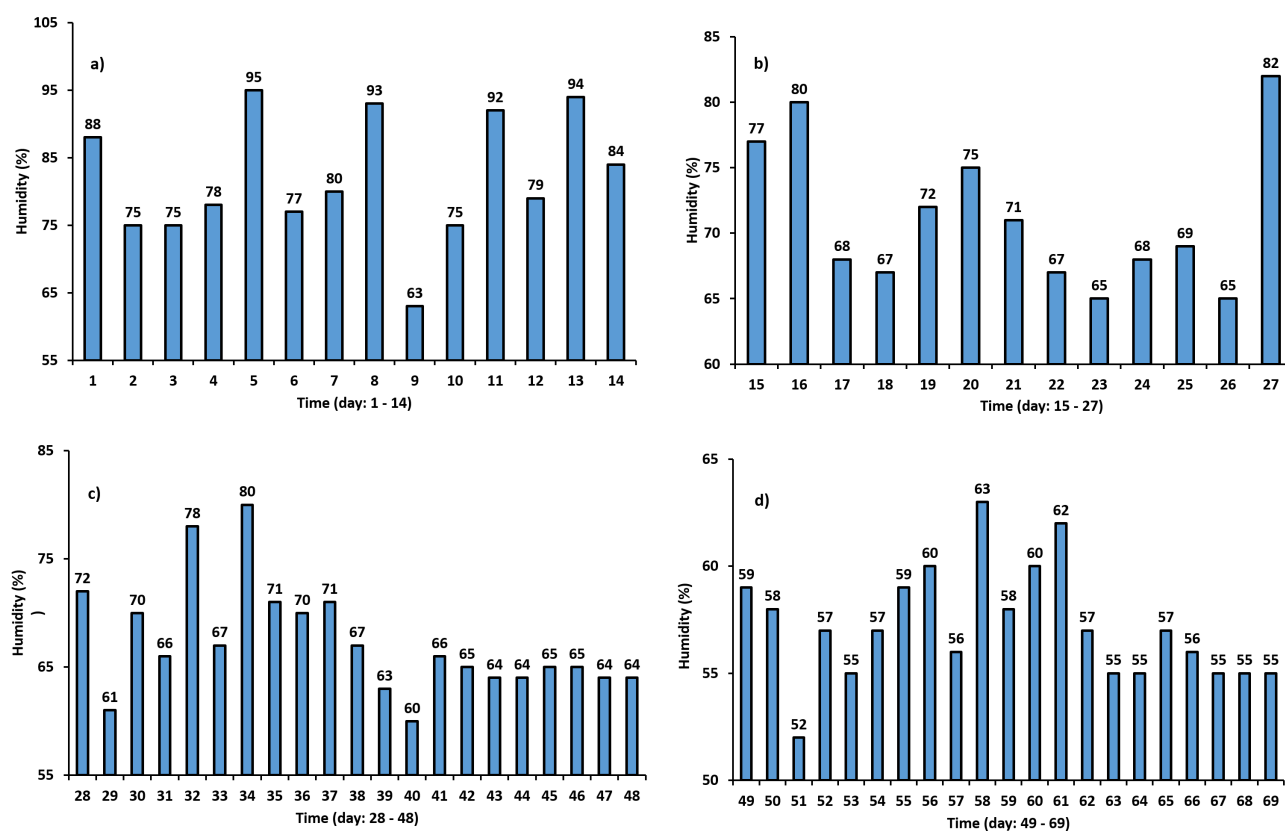


Figure 5. Moisture content of the windrow (in %) according to the stages of decomposition: (a) Mesophilic stage: initially high moisture content (55% - 65%) to support the initiation of the process, with a slight decrease towards the end of the stage; (b) Advanced mesophilic stage: maintained within the optimal range (50% - 60%), with adjustments made through watering; (c) Thermophilic phase: relatively stable moisture content (40% - 55%), with losses through evaporation being offset by water additions; (d) Maturation: a marked decrease to (35% - 45%), reflecting the stabilization of the organic matter and the cessation of intense biological activity.

The moisture content of the windrow was kept within the generally recom-

mended range of (40% - 60%) for most of the process [4] [9]. The slight fluctuations observed around the turning points can be explained by the internal redistribution of moisture and compensatory additions of water. The gradual decrease in moisture content during the maturation phase is consistent with the reduction in microbial metabolic activity and the reduced requirement for free water for enzymatic reactions.

Some authors point out that in windrows left exposed to the open air in tropical temperatures (28°C - 32°C on average), surface evaporation can remove up to 3-5 liters/m²/day during the thermophilic phase, which requires regular monitoring and moisture management [8]. In this study, the use of protective tarpaulins during periods of intense sunshine helped to limit these losses, whilst maintaining oxygen access via the sides of the windrow.

3.3. Correlations between Temperature, Water Quantity, and Moisture Content

Analysis of Pearson's correlations between the three monitored parameters over the 69-day cycle ($n = 69$ valid daily observations, 0% missing data) revealed distinct interactions across the specific phases of the process.

A positive correlation was observed between windrow temperature and the volume of water applied during the early stages, notably during the mesophilic phase (D1-D14: $r = 0.74$, 95%CI[0.35,0.91], $p = 0.003$, $n = 14$) and the advanced mesophilic phase (D15-D27: $r = 0.78$, 95%CI[0.39,0.93], $p = 0.002$, $n = 13$). During these stages, rising temperatures (~38°C-55°C) and mechanical turnings (R1 on Day 15) required variable water additions to sustain moisture between 45% and 60%. During the peak thermophilic phase (D28-D48, >55°C), water inputs were deliberately reduced, as indicated in Table 2, while moisture stabilized between 40% and 50%.

Conversely, windrow temperature and moisture content exhibited an inverse relationship across the active phases (ranging from $r = -0.61$ to $r = -0.78$, $p < 0.01$). As the windrow transitioned into the thermophilic stage (>55°C), increased thermal evaporation naturally reduced moisture levels toward 40% - 50%. When moisture was high (>55% - 60%), temperature rises were moderated by the thermal inertia of water and limited gas permeability [12] [13]. On first-differenced daily data ($\Delta X_t = X_t - X_{t-1}$), the negative daily relationship remained significant (ΔTemp vs. $\Delta \text{Moisture}$: $r = -0.48$, 95%CI[-0.65,-0.27], $p < 0.001$, $n = 68$), confirming that day-to-day temperature spikes were directly coupled with moisture loss independently of the overall seasonal trend.

Finally, water additions were positively correlated with short-term moisture replenishment evaluated over a 48-hour window ($r = 0.68$, 95%CI[0.45,0.83], $p < 0.001$), confirming the immediate effectiveness of watering after turning events (R1 at D15, R2 at D28). Over the complete 69-day cycle, this overall correlation decreased ($r = 0.31$, 95%CI[0.08,0.51], $p = 0.009$, $n = 69$) due to evaporative losses and the transition to the maturation phase (D49-D69), where minimal wa-

ter additions and ambient temperatures stabilized the final moisture content at 35% - 45%. These results are consistent with the thermohydric dynamics described by Rastogi *et al.* [7].

3.4. Compost Yield and Quality

At the end of the process, 1500 kg of fine compost was produced from the initial 4000 kg of raw materials, representing a mass yield of 37.5%. This result is consistent with the values reported in the literature for windrows of similar composition: Sow *et al.* [1] [14] report a yield of (30% - 40%) for mixed windrows in West Africa, whilst Kumar & Bhambri [8] [15] [16] cite ranges of (25% - 45%) depending on the nature of the substrates and climatic conditions.

Mass losses are mainly attributable to water evaporation (the largest component), the mineralization of organic carbon into CO₂ during aerobic microbial respiration, and gaseous losses of nitrogen (ammonia). The resulting compost had a uniform dark brown color, a loose and crumbly texture after sieving through a 10 mm sieve, an earthy odor, and no residual heat—characteristics of mature compost that meeting quality standards [3] [11] [13].

4. Conclusions

This study demonstrates the feasibility and effectiveness of a low-tech windrow composting process for the recovery of 4 metric tons of biodegradable waste in the tropical environment of Guinea. Over a 69-day monitoring period, the four successive stages of decomposition (mesophilic, advanced mesophilic, thermophilic and maturation) were clearly identified and characterized by their respective temperature, water content and moisture profiles. The three turnings carried out played a decisive role in stimulating microbial activity, exposing the entire mass to high core temperatures compatible with compost sanitization.

Analysis of the correlations between windrow temperature, the amount of water applied and moisture content has revealed a close dynamic relationship between these three parameters, which is characteristic of the active aerobic process. The positive correlation between temperature and water requirements, and the negative correlation between temperature and moisture content, provide practical guidelines for operators of community or semi-industrial composting facilities.

The yield of 37.5% obtained (1500 kg of fine compost from 4000 kg of raw material) is satisfactory given the experimental conditions and comparable to data from the regional literature. This compost can serve as a high-quality agricultural input for peri-urban farming, thereby contributing to the sustainability of local food systems.

Further analyses, including comprehensive physico-chemical characterization (pH, electrical conductivity, organic matter content, total organic carbon, total nitrogen, and mineral fraction) as well as microbiological assays (e.g., enumeration of *Salmonella* spp. and *Escherichia coli*) to experimentally validate pathogen sanitization, are recommended to fully establish the agronomic quality and safety

of the final compost. Additionally, standard phytotoxicity bioassays on sensitive test species, coupled with an evaluation of economic viability and social acceptability, will be essential to assess the potential for scaling up community-level composting platforms in Guinea.

Acknowledgements

The authors would like to thank the Guinean Institute for Environmental Research (IREG) for its logistical and financial support.

Author Contributions

Conceptualization: M.Y.B. and M.B.C.; Methodology: M.Y.B., M.A.D., and H.B.; Formal analysis and investigation: M.Y.B., T.B.B., M.O.D., and D.F.D.; Writing - original draft preparation: M.Y.B. and H. B.; Writing - review and editing: M.B.C. and H.B.; Supervision: M.B.C. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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