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VERMICOMPOST QUALITY AND ITS VARIATION ON CHANGES IN MOISTURE CONTENT

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ABSTRACT

The Government of Nepal has developed quality standards for soil-amending organic products, including vermicompost. There has been considerable debate on moisture content vis-à-vis quality parameters of commercial vermicompost. This research addressed a pertinent issue for commercialization and quality control of vermicompost by assessing changes in nutrient content upon reducing moisture in ready-to-sale products. Vermicompost samples were collected from ten commercial farms in Kathmandu Valley, Pokhara, Chitwan and Syangja at three stages of production. Samples from the marketed stage (Stage 3) were laid out in a Completely Randomized Design in trays with three replicates and dried under ambient laboratory conditions during winter. Sampling was done at different stages of moisture reduction and physico-chemical parameters were assessed. Reduction in moisture content significantly increased nitrogen content (from 1.06% to 1.46%) but there was, however, significant variation in all tested parameters among products. Phosphorus and potassium content remained unaltered upon reducing moisture to 25%. Under ambient conditions, it took 28 days on average to reduce moisture from 54.28% to 25%, though this depends on prevailing climatic conditions.

Keywords: commercial vermicompost, drying, moisture content, nutrient content, quality standard, etc.

1. INTRODUCTION

Incorporation of farm yard manure (FYM) or compost has long been the tradition of soil fertility management in Nepal. After the introduction of chemical fertilizers, promotion of mechanization, and commercialization of agriculture, the use of organic amendments was rapidly supplemented by synthetic inputs. Chemical fertilizer has since become the primary nutrient source for crop production in the Terai and Hills. However, in recent years, organic fertilizers have gained growing importance in managing soil fertility, and among these, vermicompost has attracted major attention.

Vermicompost is a natural fertilizer produced through the bio-oxidation and stabilization of organic waste by earthworms and associated microorganisms (Pathma and Sakthivel, 2012). It is increasingly recognized for its role in sustainable agriculture due to its rich composition of essential plant nutrients and beneficial microorganisms (Mohite et al., 2024). This biologically

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active material enhances soil structure, nutrient availability, and overall soil fertility (Mohite et al., 2024), and enriches soil with nitrogen, phosphorus, and potassium alongside beneficial microorganisms. The quality of vermicompost is therefore a critical factor influencing its efficacy as a soil amendment and bio-fertilizer (Bharti et al., 2025).

Moisture content is one of the most critical parameters governing vermicompost quality during production and post-harvest storage. Active vermicomposting requires high moisture conditions (typically 70–90%) to sustain earthworm activity and microbial decomposition (USDA-AMS, 2011). However, the moisture content of a finished, packaged product must be considerably lower to ensure product stability, prevent pathogen proliferation, reduce transport weight, and facilitate mechanical application. The Government of Nepal (GoN) has set quality standards for organic fertilizers, including vermicompost in dust, granular, and vermicast forms. A continuous debate has centered on moisture content: the maximum permissible moisture content for vermicompost is 25% under GoN standards. Despite this, products available in the market routinely exceed this threshold, hampering government programs to procure and subsidize vermicompost products. Moisture content is a crucial parameter dictating stability, microbial activity, and handling characteristics of commercial vermicompost, directly impacting shelf-life and agronomic value (Garg et al., 2006; Misra et al., 2003). This research was therefore conducted to study how moisture content can be reduced to the permissible level without compromising the nutrient quality of vermicompost. The main hypothesis for the research was the nutrient content will vary with moisture content. The specific objectives of the study were: (i) to assess the moisture content and quality of vermicompost during the production stage; (ii) to assess the moisture content and quality of vermicompost prepared by manufacturing companies just before packaging; and (iii) to estimate the time required for vermicompost to reach approximately 25% moisture content and to characterize nutrient content at that level.

2. METHODOLOGY

2.1 COLLECTION OF VERMICOMPOST SAMPLES

Vermicompost samples were collected from ten commercial vermicompost-producing farms in Kathmandu Valley, Pokhara, Syangja, and Chitwan during Poush month of 2079 BS (December–January 2022–23). Representative samples were collected from three defined stages of the production-to-market chain: the production stage (Stage 1), the ready-for-packing stage (Stage 2), and the ready-for-sale or packed-bag stage (Stage 3). Sufficient sample quantities were secured at each stage and transported to the laboratory for analysis and further study. Sample weights were recorded in the field immediately after collection and again upon arrival at the laboratory to monitor moisture changes during transport.

2.2 REDUCING MOISTURE OF VERMICOMPOST IN THE LABORATORY

Stage 3 samples from all ten products were weighed and placed on laboratory tables to dry under ambient temperature conditions. Each product was replicated three times in a Completely Randomized Design using trays. During field visits, it was observed that none of the sampled farms had open-air or dedicated drying infrastructure; the laboratory ambient drying was therefore designed to harmonize with conditions comparable to typical producer storage settings. Moisture content was monitored at regular intervals using a moisture meter probe followed by gravimetric weight-loss measurements. The target moisture content was 25%.

Based on the monitored moisture content, the expected final weight of vermicompost was calculated prior to completion of drying, so that the 25% moisture target could be verified. Percentage moisture loss during drying was calculated on a dry weight basis as follows:

% Moisture Loss = [(Initial Weight – Final Weight) / Final Weight] × 100

Following this formula and upon laboratory verification of moisture content, the samples were considered to have reached Stage 4 (reduced to 25% moisture content).

2.3 LABORATORY ANALYSIS

Laboratory analysis of vermicompost samples was conducted following standard procedures for: pH (1:2.0 soil:water suspension), organic carbon (OC %) by the Walkley-Black wet oxidation method, total nitrogen (N %) by the Kjeldahl method, total phosphorus (P %) by colorimetric method after acid digestion, and total potassium (K %) by flame photometry after acid digestion. All nutrient analysis were done on a dry weight basis at the National Soil Science Research Center, NARC, Khumaltar.

2.4 DATA OBSERVATION AND ANALYSIS

Periodic moisture content (measured via moisture meter probe and weight loss), nutrient content, pH, and organic carbon content were analyzed in the laboratory. Observed data were statistically analyzed for test of significance among products using GENSTAT software, and findings are presented in tabular and graphical forms. Descriptive analysis to estimate variance, range, and other statistics among tested products was performed using MINITAB. Analysis of variance (ANOVA) was done and mean separation employed the Least Significant Difference (LSD) test at the 5% probability level.

3. RESULTS AND DISCUSSION

The results from Stage 1, Stage 2, and Stage 3 samples showed high variation in moisture content and organic carbon content among the products tested (Tables 1, 2, and 3). Descriptive analysis was conducted to characterize product statistics at each stage. The moisture content during the production stage was approximately 68% (Table 1), declining to about 59% at the ready-to-sale stage (Table 2). Moisture in packed bags was found to be around 54% (Table 3) — well above the GoN standard of 25% and therefore of substandard quality. Orkmaz Belliturk (2018) reported that finished vermicompost should contain less than 35% moisture to reduce transport costs and facilitate mechanical application. Tamil Nadu Agricultural University, India recommends a minimum of 40% moisture for stored vermicompost, with water sprinkling advised to maintain quality and microbial populations (https://agritech.tnau.ac.in).

3.1 PRODUCTION STAGE (STAGE 1)

Table 1. Descriptive statistics of vermicompost samples at the production stage (Stage 1, n = 10)

Variable	Mean	SE Mean	StDev	Variance	CoefVar	Minimum	Median	Maximum	Range
Moisture (%)	67.89	2.19	6.94	48.14	10.22	53.11	67.96	77.72	24.61
pH	7.721	0.22	0.696	0.484	9.01	6.85	7.71	8.83	1.98
OC (%)	16.72	1.25	3.95	15.58	23.61	10.33	18.21	22.00	11.67
Total N (%)	0.947	0.069	0.217	0.047	22.92	0.60	0.915	1.379	0.779
Total P (%)	1.623	0.118	0.372	0.138	22.92	1.124	1.63	2.276	1.152
Total K (%)	0.866	0.132	0.419	0.175	48.33	0.35	0.80	1.43	1.08

OC = Organic Carbon; SE = Standard Error; StDev = Standard Deviation; CoefVar = Coefficient of Variation; N= Nitrogen; P=Phosphorus; K=Potassium; %=Percent; n= Number of products tested

The mean moisture content at Stage 1 was 67.89%, with a range of 24.61 percentage points (53.11–77.72%), reflecting the high variability inherent in freshly produced vermicompost. This high moisture level is expected during active production. The USDA-AMS (2011) recommends maintaining 70–90% moisture during vermicomposting to support adequate earthworm activity and microbial decomposition. Hossen et al. (2022) established 70% as optimal initial moisture content for cattle-manure based vermicomposting. Mean pH was 7.721 (near-neutral to slightly alkaline, consistent with mature earthworm castings), mean organic carbon was 16.72% (CoefVar = 23.61%), mean total N was 0.9472%, mean total P was 1.623%, and mean total K was 0.866%. The high coefficient of variation for potassium (48.33%) underscores the strong influence of feedstock materials on the final mineral nutrient composition — a widely recognized phenomenon in vermicompost production (Rakib et al., 2025; Mulatu and Bayata, 2024).

3.2 PRE-PACKING STAGE (STAGE 2)

Table 2. Descriptive statistics of vermicompost samples at the pre-packing stage (Stage 2, n = 8)

Variable	Mean	SE Mean	StDev	Variance	CoefVar	Minimum	Median	Maximum	Range
Moisture (%)	55.81	3.43	9.71	94.31	17.40	38.75	59.54	64.91	26.16
pH	7.401	0.254	0.717	0.515	9.69	6.06	7.535	8.25	2.19
OC (%)	17.34	1.00	2.84	8.07	16.39	11.81	17.86	20.27	8.46
Total N (%)	1.208	0.105	0.297	0.088	24.54	0.646	1.206	1.663	1.016
Total P (%)	1.767	0.167	0.472	0.222	26.68	1.068	1.747	2.604	1.535
Total K (%)	1.168	0.150	0.424	0.180	36.32	0.65	1.13	1.97	1.32

OC = Organic Carbon; SE = Standard Error; StDev = Standard Deviation; CoefVar = Coefficient of Variation; N= Nitrogen; P=Phosphorus; K=Potassium; %=Percent; n= Number of products tested

Mean moisture at Stage 2 declined to 55.81% from 67.89% at Stage 1, reflecting some natural moisture loss during the interval between harvest and packing, but still far above the 25% threshold. Mean pH (7.401), OC (17.34%), total N (1.208%), total P (1.767%), and total K (1.168%) all remained broadly stable or showed slight increases reflecting the modest concentration effect of partial moisture loss.

3.3 MARKETED (PACKED) STAGE (STAGE 3)

Table 3. Descriptive statistics of vermicompost samples from marketed packed bags (Stage 3, n = 10)

Variable	Mean	SE Mean	StDev	Variance	CoefVar	Minimum	Median	Maximum	Range
Moisture (%)	54.28	2.89	9.15	83.80	16.86	36.15	54.01	68.47	32.32
pH	7.49	0.243	0.767	0.589	10.37	6.42	7.555	8.53	2.11
OC (%)	17.58	0.867	2.742	7.518	15.48	13.189	18.12	21.529	8.34
Total N (%)	1.06	0.083	0.262	0.069	23.29	0.692	1.108	1.526	0.833
Total P (%)	1.72	0.118	0.372	0.138	20.85	1.382	1.713	2.622	1.24
Total K (%)	1.20	0.216	0.684	0.468	60.87	0.35	1.13	2.33	1.98

OC = Organic Carbon; SE = Standard Error; StDev = Standard Deviation; CoefVar = Coefficient of Variation; N= Nitrogen; P=Phosphorus; K=Potassium; %=Percent; n= Number of products tested

Mean moisture content in marketed products was 54.28% (range 36.15–68.47%), more than double the GoN threshold of 25%. This has significant implications: consumers purchasing products by weight are effectively paying for water rather than nutrient-rich organic matter, and the high moisture presents risks of microbial spoilage during storage and transport. High moisture also promotes ammonia volatilization during storage, which can reduce nitrogen content over time (Das et al., 2014; Varsha Kumari et al., 2021). Mean pH was 7.49, mean OC was 17.58%, mean total N was 1.06%, mean total P was 1.72%, and mean total K was 1.20%. The potassium CoefVar at Stage 3 (60.87%) was particularly elevated, reflecting diverse feedstocks and processing practices across producers. This inter-product variability is consistent with the observation that, unlike standardized chemical fertilizers, vermicompost NPK ratios are highly feedstock-dependent (Rakib et al., 2025).

3.4 EFFECT OF MOISTURE REDUCTION ON PH AND ORGANIC CARBON (STAGE 3 VS. STAGE 4)

The nutrient content of vermicompost at Stage 3 was compared with Stage 4 (after reducing moisture to 25%). The nutrients did not change substantially upon reducing moisture content to 25% (Table 4). However, the average data revealed that organic carbon (OC) increased from 17.58% to 19.89% — primarily a concentration effect resulting from water removal. The C/N ratio is a key indicator of vermicompost quality and maturity; as organic carbon concentrates upon drying, the C/N ratio may shift slightly, but this does not necessarily indicate quality deterioration (Misra et al., 2003; Lin et al., 2024). Differences in OC content were observed among individual product samples, reflecting the diversity of feedstock inputs. pH of the samples was largely unaltered upon moisture reduction, consistent with the well-buffered nature of mature vermicompost (Pathma and Sakthivel, 2012). However, the pH varied significantly among the products (Table 4).

Previous studies have explored vermicompost quality primarily focusing on feedstock combinations and their impact on nutrient enrichment and earthworm performance (Utami et al., 2025). Research indicates that vermicompost significantly enhances plant growth, increases soil microbial biomass and diversity, and acts as a source of macro- and micronutrients (Malal et al., 2024). Abbey et al. (2013) specifically reported that drying and rehydration of vermicasts did not affect nutrient bioavailability or seedling growth, further supporting the conclusion that ambient drying to 25% moisture does not compromise product agronomic value.

Table 4. Variation in pH and organic carbon content before (Stage 3) and after moisture reduction to 25% (Stage 4) (n=10)

Product/Sample (coded)	pH – Stage 3	pH – Stage 4	OC (%) – Stage 3	OC (%) – Stage 4
CD	7.53	7.55	19.11	21.83
D	6.43	6.43	15.44	18.16
P	6.47	6.54	21.53	24.56
KP	7.97	7.96	20.33	20.72
PB	7.58	7.54	17.13	17.36
BS	8.00	7.60	20.09	20.79
GD	8.02	8.01	15.62	17.88
SY	7.31	7.04	11.81	16.46
LAMA	7.03	8.50	15.36	23.82
SV	8.53	6.98	19.38	17.29
Grand Mean	**7.49**	**7.41**	**17.58**	**19.89**
LSD	–	**0.3437**	–	**4.528**
SEM ±	–	**0.1636**	–	**2.155**
F test (P>F)	–	***	–	*
CV (%)	–	**2.7**	–	**13.3**

**** $p<0.001$; * $p<0.05$; LSD = Least Significant Difference; SEM = Standard Error of Mean; CV = Coefficient of Variation; S3 = Stage 3; S4 = Stage 4*

3.5 EFFECT OF MOISTURE REDUCTION ON NITROGEN, PHOSPHORUS AND POTASSIUM

The total nitrogen content varied significantly but phosphorus, and potassium content of the vermicompost samples did not change significantly upon reducing moisture content to 25%

(Table 5). The average data showed that total nitrogen, total phosphorus, and total potassium changed from 1.06 to 1.461%, 1.72 to 1.69%, and 1.20 to 1.208%, respectively. The results revealed differences in nutrient contents among products, but no consistent detrimental effect of drying on macronutrient levels.

The increase in total nitrogen upon drying (1.06 to 1.461%) reflects a concentration effect as water is removed, rather than any biological fixation. This finding is consistent with Abbey et al. (2013), who showed that drying of vermicasts did not diminish nitrogen bioavailability. However, this differs from the high-temperature artificial drying scenario reported by Manyuchi et al. (2013), where drying fresh vermicompost at 105°C reduced total nitrogen by 31.25%, highlighting that the method and temperature of drying are critical determinants of nitrogen retention. The present study's ambient drying approach (without heat application) appears to preserve nitrogen more effectively, which is an important practical distinction for producers.

Das et al. (2014), studying nutrient dynamics in stored vermicomposts prepared from cattle manure, paddy straw, municipal solid waste, and fly ash over 180 days, found that nitrogen initially increased in the first 90–105 days before declining, while phosphorus and potassium steadily declined — a pattern driven by leaching and microbial consumption at high moisture levels. The present results suggest that reducing moisture to 25% by ambient drying effectively halts or slows these loss pathways, since the nutrient concentrations were maintained in potassium content and slightly decreased in phosphorus content. Varsha Kumari et al. (2021) similarly documented progressive decreases in N, P, K and S during storage at higher moisture contents, alongside reductions in microbial populations and enzymatic activity, underscoring the value of moisture reduction for product preservation.

Anandkumar et al. (2016) reported that moisture content of 80.32±1.6% was reduced to 23.34±3.02% in 120 days under natural conditions, and Harit et al. (2014) observed a reduction from 77.4±3.5% to approximately 20% over 90–120 days of storage. The duration required in the present study (28 days to reduce from ~54% to 25%) was shorter, likely because the initial moisture was lower and conditions were controlled indoor settings harmonizing with typical producer facilities. The high inter-product variability in potassium content (CoefVar up to 60.87%) observed across products is attributable to feedstock differences, as potassium levels in vermicompost are predominantly determined by feedstock mineral composition rather than the vermicomposting or drying process itself (Garg et al., 2006).

Table 5. Variation in total N (%), total P(%), and total K (%) before (Stage 3) and after moisture reduction to 25% (Stage 4) (n=10)

Product (coded)	N% S3	N% S4	P% S3	P% S4	K% S3	K% S4
CD	1.27	1.687	1.84	1.520	1.19	1.24
D	1.09	1.327	1.61	1.723	0.35	0.43
P	1.53	1.907	1.67	1.607	0.83	0.93
KP	1.35	1.503	1.79	1.343	1.73	1.74

Product (coded)	N% S3	N% S4	P% S3	P% S4	K% S3	K% S4
PB	1.12	1.613	2.62	1.897	1.07	0.87
BS	0.97	1.150	1.38	1.897	1.19	1.17
GD	0.69	1.447	1.75	1.527	1.79	1.72
SY	0.65	1.093	1.59	1.537	0.83	0.81
LAMA	1.10	1.587	1.50	1.783	0.65	2.35
SV	0.78	1.300	1.48	2.073	2.33	0.81
Grand Mean	**1.06**	**1.461**	**1.72**	**1.651**	**1.20**	**1.208**
LSD	–	**0.2402**	–	**0.3681**	–	**0.1656**
SEM ±	–	**0.1144**	–	**0.1752**	–	**0.0788**
F test (P>F)	–	***	–	*	–	***
CV (%)	–	**5.6**	–	**12.7**	–	**8.0**

**** $p<0.001$; * $p<0.05$; LSD = Least Significant Difference; SEM = Standard Error of Mean; CV = Coefficient of Variation; S3 = Stage 3; S4 = Stage 4; N= Nitrogen; P=Phosphorus; K=Potassium; %=Percent; n= Number of products*

3.6. RELATIONSHIP BETWEEN MOISTURE REDUCTION AND DURATION OF DRYING UNDER NATURAL CONDITION

The moisture content of the samples was observed at regular intervals and a moisture content vs. duration curve was plotted (Figure 1). The results showed that increasing number of drying days reduced the moisture content in a declining curve typical of evaporative drying under ambient conditions. Mean values of the samples indicated that reaching 25% moisture content required 28 days on average. However, this may vary with season and diurnal temperature and humidity fluctuations.

The drying rate observed in this study — approximately 28 days under winter ambient indoor conditions — is considerably faster than the 90–120 days reported by Harit et al. (2014) and Anandkumar et al. (2016) under comparable natural conditions, owing primarily to the lower initial moisture content of the Stage 3 samples (~54%) compared to freshly harvested vermicompost (~77–80%). Kleawklaharn and Iwai (2014) demonstrated that storage duration significantly influences vermicompost quality, with longer storage at high moisture leading to deterioration of nutrient content. This underscores the practical importance of rapid moisture reduction: by bringing moisture to 25% within 28 days, producers can arrest the nutrient deterioration associated with prolonged high-moisture storage.

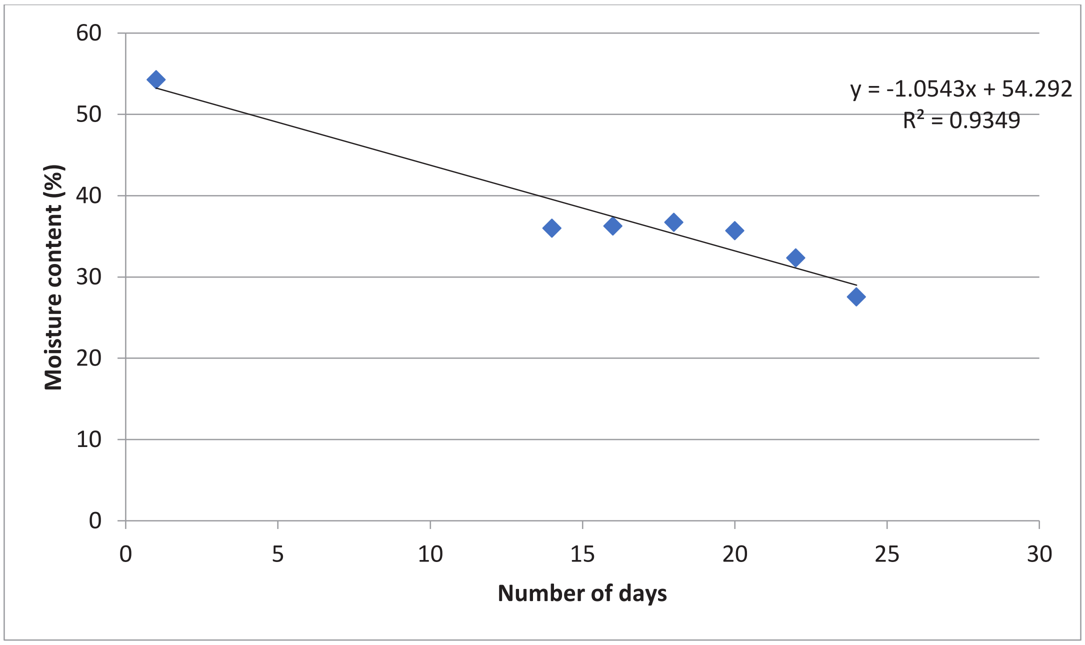

Figure 1. Moisture content (%) versus drying duration (days) under ambient laboratory conditions — mean across all products (n=11, three replicates each)

While comparing the moisture content at various stages of the production chain with their nutrient contents, results showed no significant correlation between moisture content and nutrient content of the vermicompost samples (Figure 2). There was a slight but non-significant increment in nitrogen content of vermicompost on reducing the moisture content of the product.

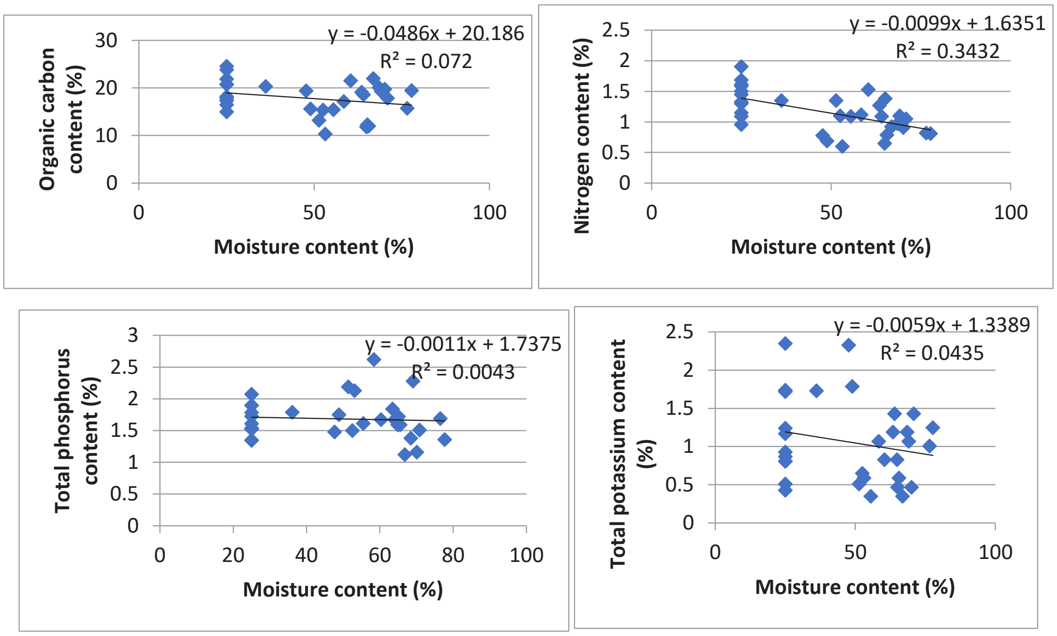

Figure 2. Correlation between moisture content (%) and nutrient concentrations (N, P, K) across vermicompost samples at different production stages

4. SUMMARY AND CONCLUSION

Reduction in the moisture content of vermicompost significantly increased nitrogen content of the products and there was significant variation in all tested parameters among the products. Regarding phosphorus, it slightly decreased and potassium content remained largely unaltered upon reducing moisture content to 25%. Under ambient (natural) conditions during winter, it took an average of 28 days to reduce moisture from 54.28% to 25%. This duration is expected to vary with climatic condition and season.

The findings confirm that reducing vermicompost moisture to the GoN-mandated limit of 25% does not compromise — and in several respects improves — its nutrient quality on a dry weight basis. The concentration of nitrogen and organic carbon increases as a result of water removal, making the dried product more potent per unit weight without any harmful processing. The lack of correlation between moisture content and nutrient content across products further confirms that nutrient quality is primarily determined by feedstock composition rather than moisture level per se.

The present study provides evidence that producers can adhere to the GoN standard of 25% maximum moisture which can be achieved through appropriate post-harvest ambient drying without loss of product quality. It is therefore recommended to go for post-harvest drying in order to comply with the moisture content standard of vermicompost.

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ANNEXES

Annex 1

Moisture Content, pH, and Organic Carbon (%) of Vermicompost at Different Production Stages

Product (codes)	MC% S1	pH S1	OC% S1	MC% S2	pH S2	OC% S2	MC% S3	pH S3	OC% S3
CD	69.07	7.25	19.30	62.53	7.75	18.87	63.47	7.53	19.11
D	66.85	6.88	22.00	54.82	6.74	15.18	55.50	6.43	15.44
P	70.10	6.85	19.76	43.27	6.06	20.27	60.37	6.47	21.53
KP	64.06	7.86	18.57	38.75	8.03	18.40	36.15	7.97	20.33
PB	70.88	8.53	17.86	58.51	7.74	17.31	58.40	7.58	17.13
BS	76.48	8.11	15.73	63.11	7.33	20.27	68.47	8.00	20.09
GD	77.72	8.21	19.42	60.56	8.25	16.58	48.89	8.02	15.62
SY	65.55	7.13	11.95	64.91	7.31	11.81	–	–	–
LAMA	65.10	7.56	12.26	–	–	–	52.52	7.03	15.36
SV	–	–	–	–	–	–	47.68	8.53	19.38

MC = Moisture Content; OC = Organic Carbon; S1 = Stage 1; S2 = Stage 2; S3 = Stage 3; '–' = sample not available

Annex 2:

Total N (%), P (%), and K (%) of Vermicompost at Different Production Stages

Products (codes)	N% S1	P% S1	K% S1	N% S2	P% S2	K% S2	N% S3	P% S3	K% S3
CD	1.10	2.28	1.07	1.19	1.46	1.19	1.27	1.84	1.19
D	0.92	1.12	0.35	1.06	1.07	0.65	1.09	1.61	0.35
P	0.91	1.16	0.47	1.66	1.68	0.89	1.53	1.67	0.83
KP	1.09	1.67	1.43	1.22	2.18	1.55	1.35	1.79	1.73
PB	1.05	1.51	1.43	1.32	2.60	1.07	1.12	2.62	1.07
BS	0.82	1.69	1.01	1.12	1.47	1.19	0.97	1.38	1.19
GD	0.81	1.36	1.25	1.43	1.85	1.97	0.69	1.75	1.79
SY	0.79	1.59	0.59	0.65	1.81	0.83	–	–	–
LAMA	1.38	1.72	0.47	–	–	–	1.10	1.50	0.65
SV	–	–	–	–	–	–	0.78	1.48	2.33

N = Total Nitrogen; P = Total Phosphorus (as P_2O_5); K = Total Potassium (as K_2O); S1–S3 = Stages 1–3; '–' = sample not available