



Value Addition of Cow Dung Compost through Single Screw Extrusion Process

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ABSTRACT

Background: Single-screw extrusion is an innovative method for improving cow dung composting and addressing traditional challenges like nutrient loss. Single-screw extrusion significantly enhances cow dung composting by improving nutrient retention (notably N and P) and accelerating decomposition.

Methods: Fresh cow dung was processed through traditional composting and single-screw extrusion composting and fresh cow dung was used as a control. The extrusion process employed optimized mechanical parameters (600 rpm screw speed) before composting. The compost pit was monitored throughout the 3-month process. The temperature averaged 34°C initially, peaked at 62°C during the thermophilic phase and stabilized at 32°C during maturation, confirming successful decomposition. All treatments were analyzed for moisture content, C: N ratio, ash, organic matter, macronutrients (N, P, K, S) and heavy metals (Cd, Cr, Ni). Statistical comparison (ANOVA, $p < 0.05$) also determined significant differences between processing methods.

Result: The study found that moisture reduction (25%) and a declining C: N ratio (from ~38 to <20) reflected intense microbial activity, while pH stabilization (7.16) indicated compost maturity, with optimal moisture, aeration and nutrient balance ensuring efficient decomposition. Conventional composting resulted in substantial nutrient losses, with nitrogen (N) decreasing by 16.4% (from 1.22% to 1.02%), phosphorus (P) by 7.4% (from 0.27% to 0.25%), potassium (K) by 52.2% (from 0.69% to 0.33%) and sulfur (S) by 34.0% (from 1.03% to 0.68%). In contrast, single-screw extrusion significantly improved nutrient recovery, increasing N by 26.2% (from 1.22% to 1.54%) and P by 11.1% (from 0.27% to 0.30%), while still showing reductions in K by 49.2% (from 0.69% to 0.35%) and S by 34.0% (from 1.03% to 0.68%). Micronutrient analysis revealed stable zinc levels (0.01%), a threefold increase in copper from 0.001% to 0.003% and a doubling of boron levels (from 0.001% to 0.002%) in extruded compost, revealing enhanced nutrient concentration during extrusion. These findings highlight extrusion composting as a promising method for nutrient retention and compost quality improvement.

Key words: Cow dung composting, Nutrient retention, Single screw extrusion, Value added compost.

INTRODUCTION

Bangladesh produces approximately 156 million metric tons of cattle manure annually, which poses a major waste management challenge (DLS, 2022), while simultaneously offering a vast, untapped resource for sustainable solutions. However, untreated storage and open dumping causes significant nutrient loss, which could otherwise be utilized in crop production (Kabir *et al.*, 2022). Cow dung is a rich source of organic matter, essential nutrients such as nitrogen, phosphorus and potassium, as well as beneficial microorganisms that can enhance soil fertility and plant growth (Patra and Bharti, 2024). Moreover, inadequate waste management practices lead to environmental pollution through the release of nitrate, phosphate, heavy metals and greenhouse gas, highlighting the urgent need for sustainable waste treatment solutions. However, heavy metal poisoning of agricultural soils poses a serious risk to plant life, human health and global food supply. When heavy metal levels in agricultural soils get to dangerous levels, it harms crop health and yield (Prodipto *et al.*, 2024). Manure containing heavy metal pollutants such as Cd, Pb, Cu, Zn, etc. is a much greater threat to agrobiogeocenoses and, in particular, to the soil (Vasylovych, 2024).

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Composting is a self-heating, aerobic, bio-decomposition process of organic waste that offers advantages over other disposal strategies (Mckenzie *et al.*, 2022). It is a sustainable and effective solution for managing organic waste, transforming it into stable, nutrient-rich and non-toxic compost ideal for agricultural use (Bustamante *et al.*, 2008; Canet *et al.*, 2008; Shahudin *et al.*, 2013). Traditional composting is time-consuming (3-6 months) and often suffers from nutrient losses, especially nitrogen, along with risks of odor, greenhouse gas emissions, pests and incomplete pathogen destruction. It also produces a bulky, non-uniform, low-nutrient product that is costly to transport and may cause phytotoxic effects if not fully stabilized. Manure management systems like compost bedded pack system improves animal comfort and reduces heat stress (Dhakal *et al.*, 2023). Advanced composting techniques are increasingly being adopted to reduce nutrient losses and environmental impacts, including emissions of ammonia, hydrogen sulfide and methane, as well as problems caused by flies and rodents (Parkinson *et al.*, 2004).

Integrating mechanical pretreatment, such as single-screw extrusion, with microbial inoculation presents a transformative approach to cow dung composting. The screw extruder breaks down the organic matter, thereby increasing the surface area, similar to rotary drum treatment, which has been found effective in producing fine-grained material (Kalamdhad *et al.*, 2009; Singh *et al.*, 2009). The nutrient content of compost is significantly improved through inoculation with beneficial microorganisms, leading to better soil fertility and physical stability, which supports sustainable crop productivity (Yamada and Xu, 2001; Jahangir *et al.*, 2021). The addition of microbial inoculants accelerates the decomposition of organic matter, leading to faster compost maturation (Wongkoon *et al.*, 2017; Salih *et al.*, 2025). This biologically enriched compost subsequently improves plant growth by improving nutrient availability and stimulating beneficial soil biological activity (Zailani *et al.*, 2017). By converting cow dung into nutrient-rich compost through single screw extruded mechanical treatment and IMO (Indigenous Microorganisms) inoculation, farmers can mitigate nutrient loss, produce compost that is safe for agricultural use. Micronutrients such as boron (B), copper (Cu) and zinc (Zn) are essential for plant growth, though required in trace amounts (Ramnarain *et al.*, 2018). Additionally, the use of organic fertilizers improves crop production by improving soil health and reduces the reliance on imported chemical fertilizers (Salam *et al.*, 2021).

The aim of this study is to improve cow dung composting by integrating single-screw extrusion as a mechanical pretreatment with indigenous microorganism (IMO) inoculation, as an innovative approach to enhance compost quality. Additionally, this study compares extruded and traditional cattle dung compost to improve manure management through analysis of their physicochemical properties, nutrient content and heavy metal concentrations.

MATERIALS AND METHODS

For this study, fresh cow dung was collected from cattle farmers in the Naogaon and Chuadanga districts of northern Bangladesh during June 2023 to May 2025 to serve as a control sample. The cow dung compost (treatment) samples were also obtained from the same sources but processed using two distinct methods. The first method involved traditional composting, where untreated mixtures of straw, bedding materials and fresh cow dung were stored for extended periods. The second method used single-screw extruded composting, in which fresh cow dung was mechanically treated and mixed with residual feed straw and bedding materials. Mature compost samples were collected from four replicate piles of each treatment, including both traditional cow dung compost and single-screw extruded cow dung compost. The collected samples were sieved using a sieve with a pore size of 0.5 mm to achieve a uniform particle size of less than 0.5 mm. The samples were analyzed at the Soil Research Development Institute (SRDI) and Bangladesh Agricultural University (BAU) for physicochemical properties (moisture, pH, organic carbon, organic matter, ash), nutrient content (N, P, S, K, B, Zn) and heavy metals (Pb, Cd, Cr, Ni) using atomic absorption spectrometry (AAS).

Prior to the start of the composting process, non-compostable materials (metals, plastics, rubber and bottles) were manually removed from the cow dung by handpicking. For traditional cow dung composting, untreated cow dung was stacked in a 27 cubic-foot concrete pit without mechanical or microbial treatment. The single-screw extruded composting process was started by an electric motor-driven single-screw extruder. Fresh cow dung was mechanically treated to break down particles, ensuring uniformity and increased surface area for microbial activity (Fig 1). The extruded cow dung was then inoculated with indigenous microorganisms (IMOs) and placed in a pit of identical size to the conventional compost pile. The first turning was performed when the compost temperature exceeded 60°C, followed by biweekly turnings until the ambient temperature reached 32°C (Fig 2). The compost pit was monitored throughout the 3-month process, with initial averages at 34°C, peaking at 62°C during the thermophilic phase and stabilizing at 32°C during maturation, confirming successful decomposition. All management practices remained the same as conventional composting. The single-screw extruded cow dung compost matured 15 days earlier than traditional compost, as the pile temperature stabilized at 32°C by day 75 (Fig 2).

The moisture content was determined by oven drying method at 105°C until a constant weight was achieved, while pH was measured in a 1:2.5 compost-to-water suspension following standard methods (MAPA, 1994). Organic carbon (OC) content was analyzed using the wet oxidation method and organic matter (OM) was calculated

by multiplying OC by the conversion factor of 1.72. Ash content was calculated using the formula as described by Larney *et al.* (2005):

$$\text{Ash (\%)} = 100 - \text{Organic Matter (\%)}$$

Total nitrogen (N) content was determined using the Kjeldahl method, which involved digestion, distillation and titration to quantify nitrogen concentration. Phosphorus (P) and sulfur (S) were analyzed by digesting compost samples, followed by spectrophotometric measurement. Potassium (K) levels were determined using flame photometry, while boron (B) and zinc (Zn) content was measured via atomic absorption spectrophotometry. Heavy metals, including lead (Pb), cadmium (Cd), chromium (Cr) and nickel (Ni), were quantified by atomic absorption spectrometry (AAS) (Xu *et al.*, 2023). Statistical analysis was performed using Minitab 17.1.0, applying one-way ANOVA followed by Tukey's post-hoc test at a significance level of $p < 0.05$.

RESULTS AND DISCUSSION

Physiochemical properties

Moisture content, temperature, pH and C: N ratio are among the most important factors for carrying out composting

(Lalremruati and Devi, 2023). Among these, moisture content plays a fundamental role in microbial activity and nutrient transport across cell membranes (Roman *et al.*, 2015). The decline in moisture content observed in this study can be attributed to microbial metabolic activity, heat generation during organic matter decomposition and water loss due to aeration during pile turning (Gigliotti *et al.*, 2012). The extruded compost exhibited the lowest moisture content (25.00%) (Table 1), indicating that improved microbial activity may play a key role in regulating optimal moisture levels (Makan *et al.*, 2013). Another key indicator of compost maturity is the C:N ratio, which progressively decreased from initial values (~38% organic carbon in fresh cow dung) to stabilized levels (~23% organic carbon in mature compost) (Table 1). This reduction is driven by microbial degradation of labile carbon compounds (e.g., cellulose and hemicellulose) and the stabilization of nitrogen (Liang *et al.*, 2017; Meena *et al.*, 2021). A C:N ratio below 20 was achieved, likely due to CO_2 mineralization and occasional CH_4 production, both of which are byproducts of intensified microbial activity. These findings align with previous studies, reinforcing that microbial decomposition is central to organic matter transformation and compost maturation. (Khalib *et al.*, 2018; He *et al.*, 2000).

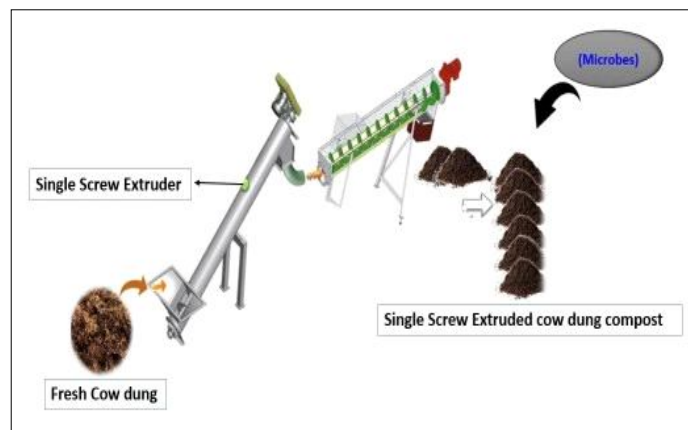


Fig 1: Single screw extrusion cow dung composting process.

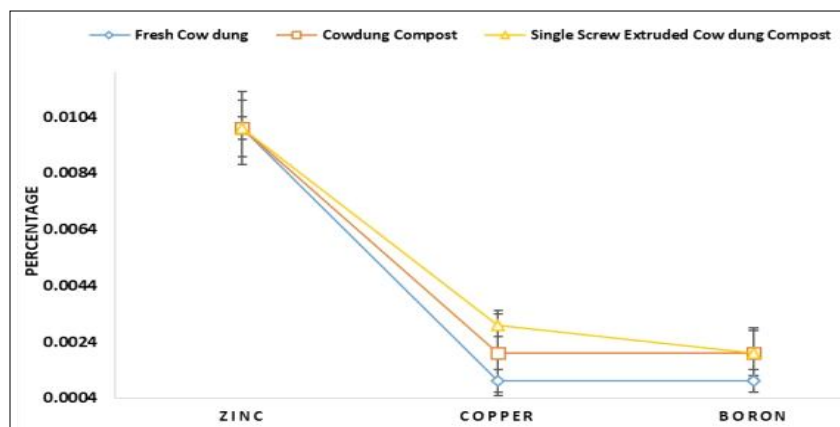


Fig 2: Micronutrient contents on fresh cow dung, cow dung compost, single screw extruded cow dung compost.

The higher pH of extruded compost (7.16) compared to fresh cow dung (6.80) reflects the typical pH evolution during composting (Table 1). Initially, organic acid production lowers pH, followed by alkalization as protein hydrolysis releases ammonia. The pH then stabilizes as ammonia volatilizes (particularly above pH 8) before eventually reaching neutralization (Xu *et al.*, 2023). The near-neutral pH of the extruded compost confirms its stability and quality, as excessively acidic or alkaline conditions can hinder microbial activity and nutrient availability. The microbial transformation of organic waste into stable compost requires optimal physicochemical conditions, particularly moisture, pH, C: N ratio and aeration. These factors interact synergistically to enhance decomposition efficiency while reducing nutrient losses (Xie *et al.*, 2025).

Total nitrogen

Fresh cow dung contained 1.22% total nitrogen (TN); however, its direct application is limited due to the presence of unstable organic compounds that can cause nitrogen immobilization and phytotoxicity (Zhang *et al.*, 2020). Nitrogen transformation during composting is crucial for stabilizing organic matter and enhancing its agronomic value. Conventional composting reduces TN to 1.02%, indicating a 16.4% nitrogen loss, primarily through nitrification, ammonia volatilization and leaching (Sanchez-Monedero *et al.*, 2001). In contrast, single-screw extrusion composting significantly enhances nitrogen retention, yielding a final TN of 1.54%, which represents a 26.2% increase and a 51% improvement over conventional compost (Table 2). This superior nitrogen recovery is attributed to the intensive cutting, mixing and homogenization effects of the extruder. These processes enhance microbial nitrogen cycling and reduce volatilization

losses by creating physical conditions that protect and stabilize nitrogen (Khalib *et al.*, 2018).

Phosphorus

Phosphorus (P) availability varied significantly among treatments. Fresh cow dung contained 0.27% P, which decreased slightly to 0.25% after conventional composting, indicating a 7.4% loss attributed to leaching and microbial immobilization. Single-screw extrusion composting resulted in the highest P content (0.30%), representing an 11.1% increase over fresh dung and demonstrating markedly superior retention efficiency (Table 2). The enhanced P availability in extruded compost can be attributed to optimized microbial activity, an improved C/N ratio and effective mechanical mixing (Traore *et al.*, 1999; Eneji *et al.*, 2003; Adler and Sikora, 2004). These results align with previous studies (Kalamdhad *et al.*, 2009; Singh *et al.*, 2009) and confirm that single-screw extrusion significantly improves phosphorus nutrient recycling efficiency.

Potassium

Potassium (K) content was significantly higher in fresh cow dung (0.69%) compared to both conventional compost (0.33%) and single-screw extruded compost (0.35%). The substantial reduction in K during composting is primarily attributed to its high solubility, which promotes leaching losses, along with possible pH fluctuations during the process (Jusoh *et al.*, 2013). Potassium depletion occurred under both composting methods; however, extruded compost retained slightly more K (3% higher) than conventional compost (Table 2), indicating marginally better K conservation under extrusion. Despite this, K remains the most loss-prone macronutrient during composting due to its mobile nature.

Table 1: Physiochemical properties of fresh cow dung, cow dung compost and screw extruded cow dung compost.

Content	Fresh cow dung (Mean±SEM)	Cow dung compost (Mean±SEM)	Single screw extruded cow dung compost (Mean±SEM)
Moisture (%)	90.00±0.58 ^a	32.33±0.66 ^b	25.00±0.57 ^c
C:N	38.76±0.39 ^a	31.13±0.37 ^b	15.20±0.82 ^c
pH	06.80±0.05 ^c	07.81±0.03 ^a	07.16±0.03 ^b
Organic Matter(%)	67.08±0.52 ^a	55.52±0.71 ^b	40.96±0.54 ^c
Organic Carbon (%)	38.95±1.21 ^a	31.74±0.77 ^b	23.40±0.39 ^c
Ash (%)	36.98±0.82 ^c	44.45±0.67 ^b	59.05±0.32 ^a

Means that do not contain the same letter are significantly ($P \leq 0.05$) different within the row.

Table 2: Nutrient dynamics in cow dung compost vs. single screw extruded cow dung compost.

Nutrient	Composted cow dung (% change)	Extruded compost (% change)	Remarks
Nitrogen	-16.4% (↓)	+26.2% (↑)	Extrusion reverses composting loss.
Phosphorus	-7.4% (↓)	+11.1% (↑)	Extrusion slightly improves P over fresh dung.
Potassium	-52.2% (↓)	-49.3% (↓)	K loss persists.
Sulfur	-34.0% (↓)	-34.0% (↓)	Both processes reduce S equally.
Copper	+100% (↑)	+200% (↑)	Extrusion triples Cu vs. fresh dung.

Sulfur

Sulfur (S) content exhibited a distinct pattern, with fresh cow dung retaining the highest levels (1.03%) due to minimal processing losses. In contrast, both composting methods resulted in significant S reductions (34%) (Table 2), likely due to volatilization and leaching during prolonged storage, stabilizing at 0.68% in the final compost. These losses align with previous findings indicating that sulfur dynamics are highly dependent on feedstock composition (Jakubus and Graczyk, 2019).

Micro-nutrients

Zinc (Zn) content remained stable (0.01%) across fresh cow dung, conventional compost and single-screw extruded compost (Fig 3), reflecting its strong binding with organic matter and resistance to leaching. In contrast, copper (Cu) concentration increased markedly from 0.001% in fresh dung to 0.003% in extruded compost, indicating a clear concentration effect due to organic matter degradation during composting. Similarly, boron (B) content

increased slightly from 0.001% to 0.002%, despite its high solubility and susceptibility to leaching, suggesting partial retention under controlled composting conditions (Bolan *et al.*, 2023). These findings confirm distinct micronutrient behaviors during composting: Zn remains chemically stable and immobile, Cu accumulates due to mass reduction and organic matter concentration and B shows intermediate mobility with partial retention. Consistent with previous studies (Kalamdhad *et al.*, 2009; Singh *et al.*, 2009), the results further demonstrate that single-screw extrusion enhances micronutrient recycling efficiency, particularly for copper.

Heavy metal contents

The analysis of heavy metals (Fig 4) in fresh cow dung and composted products reveals distinct patterns while no detectable lead (Pb) was found in any sample, fresh cow dung exhibited the highest cadmium (Cd) content (2.51 ppm) and the lowest chromium (Cr) levels (4.5 ppm). Cadmium (Cd) concentrations reduced significantly (0.47

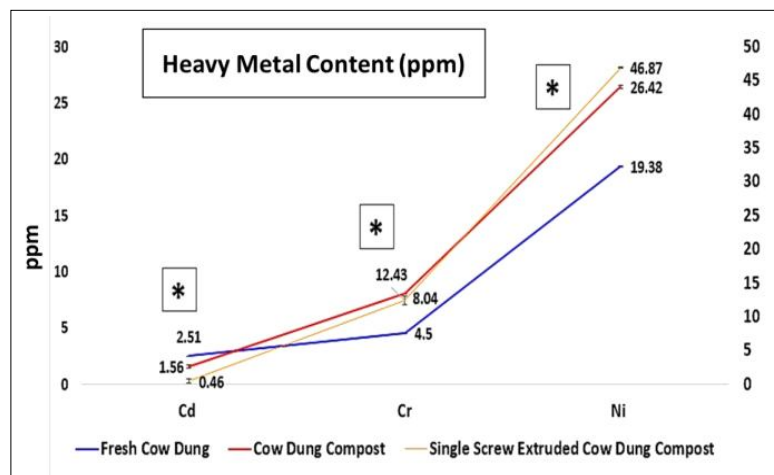


Fig 3: Heavy metal content of fresh cow dung, cow dung compost, single screw extruded cow dung compost.

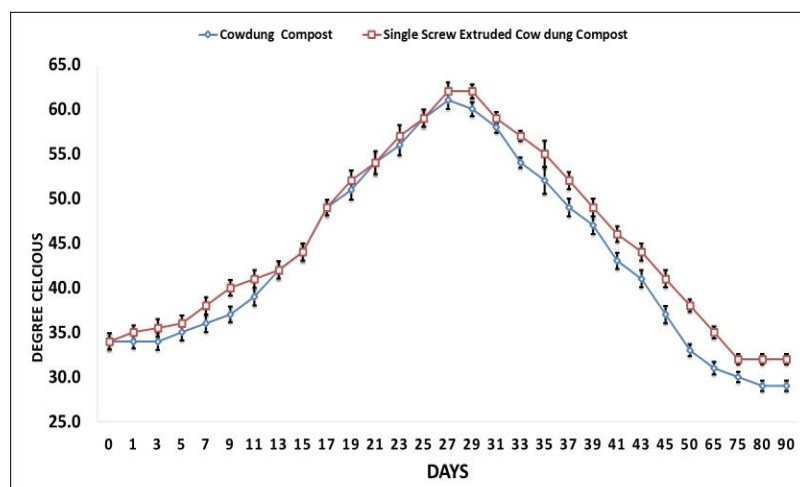


Fig 4: Temperature profile of cow dung compost and single screw extruded cow dung compost.

ppm) during composting processes, particularly single-screw extrusion. Mechanically treated extruded cow dung compost showed the highest Ni content (46.87 ppm); however, nickel (Ni) levels were increased in all sample composted products. Extruded composting does not uniformly mitigate all heavy metals, but Cr and Ni levels remained within permissible limits (Nicholson *et al.*, 1999; Font-Palma, 2019).

CONCLUSION

Single-screw extruded composting outperforms traditional methods by significantly improving nitrogen and phosphorus retention while reducing nutrient losses. However, potassium levels still declined due to its high solubility, posing a persistent challenge. Micronutrient behavior varied, with stable zinc levels but increased copper and boron concentrations, likely from enhanced organic breakdown. Heavy metal analysis revealed reduced cadmium content, though nickel levels rose slightly but remained within safe limits. Overall, this method enhances compost quality by minimizing nutrient losses and boosting agronomic value for sustainable farming.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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