# *Original Research Article*

# Design, Fabrication, and Evaluation of a Cow Dung Dewatering Machine for Small farms

## ABSTRACT

This study presents the design and development of a screw auger-based cow dung dewatering machine tailored for smallholder dairy farms. The machine was developed to address the challenges of high-moisture manure management by providing a compact, cost-effective, and field-serviceable solution. A 3 HP (2.24 kW) motor coupled with a 1:40 gearbox delivered high torque to a constant-pitch auger for solid-liquid separation. The key components including shaft, bearings, filter, and pressure plate were selected and optimized through mathematical modelling and practical trials. The system achieved consistent moisture reduction and throughput, supporting its applicability for decentralized agricultural waste processing.

## 1. INTRODUCTION

Smallholder dairy farms face persistent challenges in managing cow dung, which accumulate in large volumes due to increased livestock density. Traditional handling methods fail to cope with the dung’s high moisture content (80–90%), making it unsuitable for direct field application, storage, or transport. The lack of low-cost, efficient dewatering equipment hinders sustainable manure management, especially for farmers with limited resources.

Conventional methods such as pit storage or open dumping often result in nutrient losses, labor inefficiencies, and environmental hazards (Nkoa, 2014). While mechanical dewatering, particularly screw auger technology, proved effective in reducing manure volume and moisture, these systems remain largely inaccessible to smallholders due to cost, maintenance complexity, and unsuitability for heterogeneous organic material (Senfter et al., 2024; University of Wisconsin–Madison, 2021). Commercial models are overbuilt for rural applications and fail to address the economic constraints and variable feedstock conditions typical of small farms.

Prior studies by Jin et al. (2019), Kataria et al. (2018), and Kumar and Singh (2021) evaluated the torque-performance trade-offs in screw press dewatering systems, confirming the suitability of constant-pitch augers and optimized motor-pairing strategies. Lee et al. (2022) further demonstrated the effectiveness of screw-based separation through simulation-based biomass trials. The design of filter geometry and surface area was guided by methodologies reviewed by Nkoa (2014), Ofori and Dziedzoave (2013), and El Idrissi et al. (2023), all of whom emphasized the critical role of filter porosity and slit area in achieving efficient separation without clogging. Studies by Singh et al. (2020) and Prasad et al. (2023) have shown that moisture reduction efficiency is highly sensitive to filter slit width and applied compression pressure.

Recent literature emphasized the need for decentralized and affordable manure processing systems, calling for designs that use simple mechanisms and local materials while remaining resilient to clogging and capable of adjusting moisture levels (Prapaspongsa et al., 2010). In response, this study developed a compact screw auger-based dewatering machine tailored for cow dung and smallholder conditions. The system was designed for mechanical simplicity, low maintenance, and field adaptability, with its performance evaluated across key parameters including throughput, moisture reduction, and energy efficiency.

## 2. MATERIALS AND METHODS

The research followed a structured engineering design methodology involving four phases: requirement analysis, design and development, fabrication and performance evaluation.

### 2.1 REQUIREMENT ANALYSIS

Feedback was collected from smallholder dairy farms managing between one and ten cattle. Farmers identified major challenges such as odour, labour intensity, drudgery and space constraints in composting. The demand for a compact, reliable, and energy-efficient solution was evident.

### 2.2 DESIGN AND DEVELOPMENT



Fig: 1: Cow dung dewatering machine

The machine concept relied on single-screw auger mechanics suited to the rheological behaviour of cow dung.

#### 2.2.1 SHAFT AND SCREW AUGER DESIGN

A survey of commercially available single-phase electric motors ranging from 0.5 HP to 3 HP was conducted to identify a unit suitable for small-farm operation. Selection criteria included market availability, power rating, and grid compatibility. The optimal choice, determined through torque-speed performance calculations, was a single-phase 3 HP (2.24 kW), 1440 rpm motor, offering the required mechanical power while aligning with commonly available equipment in rural settings. Each candidate motor was analytically paired with a 1:40 single-stage worm gearbox to achieve a low output speed of 36 rpm essential for compressing viscous organic material. Torque generation, shaft stress, and pressure requirements (Table 1) were computed using standard power-to-torque conversions.

The 3 HP configuration produced a maximum shaft torque of approximately 593.45 Nm, outperforming lower-rated options and proving mathematically optimal for the system’s load and operational demands. A review by Honkalas et al. (2021) supports the selection of a single-stage, 1:40 worm gearbox, highlighting its compact design, substantial torque multiplication, quiet operation, and self-locking characteristics particularly beneficial for slurry dewatering systems.

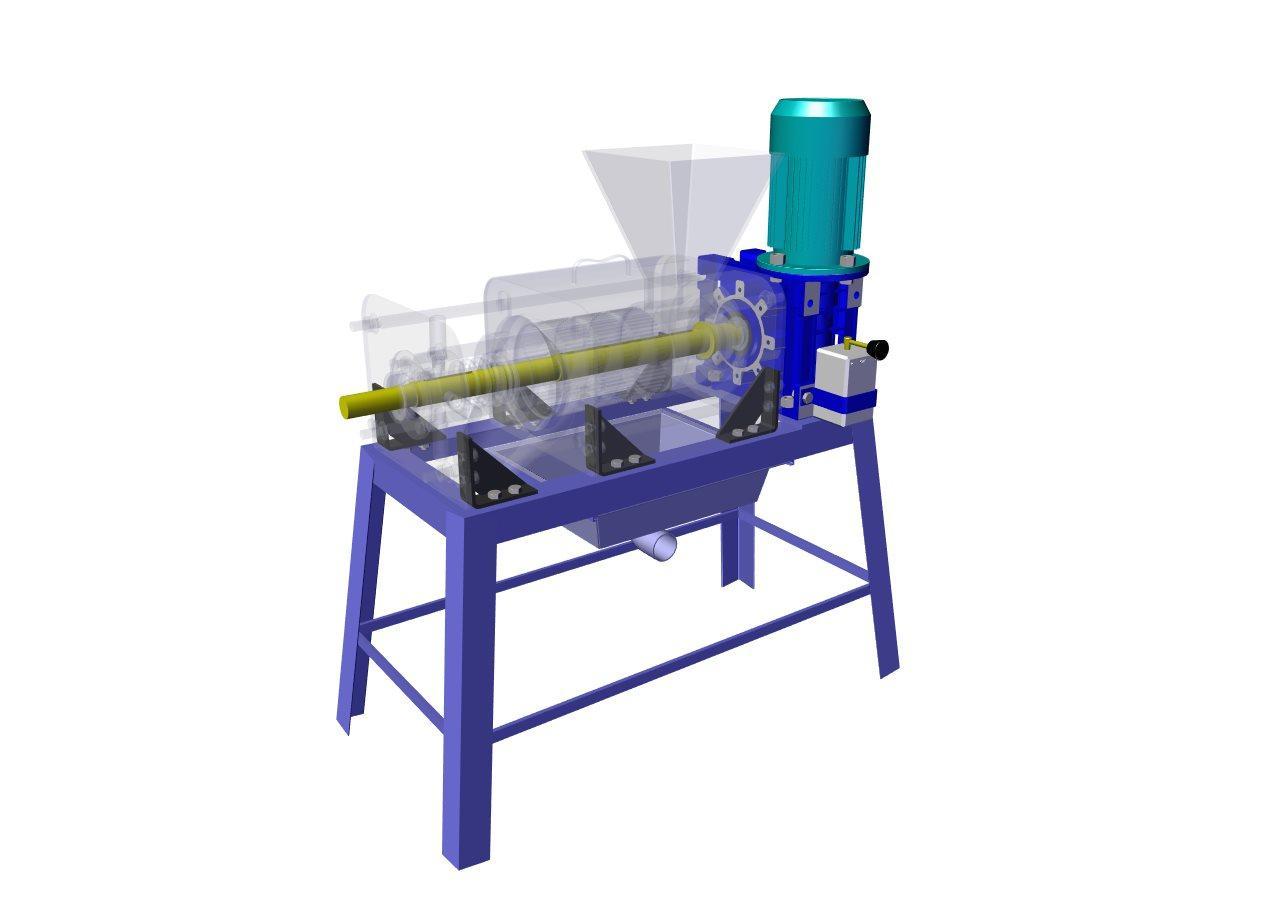


Fig 2: Shaft assembly.

Torque was determined using the motor power and shaft speed based on the standard mechanical design formulation (Shigley & Mischke, 2002). Based on the gearbox output torque: to determine the size of the shaft, the required torque is first calculated:

Applying the torsional shear stress formula for a solid circular shaft where d is shaft diameter:

The minimum shaft diameter was derived using the torsional shear stress formula:

Applying the bearing‐Spacing Rule for Shaft Length:

20d ≤ L ≤ 40d:

Were:

* 9550 is unit-conversion factor to convert power in kW and speed to torque in Nm
* P is power (kW)
* is rpm
* T is shaft torque (Nmm)
* τ\_allow is allowable shear stress = 210 / 4 = 52.5 N/
* J is polar moment of inertia (m⁴)
* r is shaft radius (m)
* L(min)​ is minimum distance between bearings (unsupported span)
* d is shaft diameter
* k is empirical multiplier, typically 20 to avoid excessive bending and misalignment under load
* L is unsupported span between bearings
* D is shaft diameter

Structural integrity is ensured by supporting the shaft over a span of 920 mm, diameter to maintain stiffness and alignment. Final mechanical durability is guaranteed using tapered roller bearings in oil-sealed housings, providing long-term stability and protection against slurry access.

This resulted in a theoretical minimum shaft diameter of 38.6 mm. Applying a Factor of Safety of 4.0, the final selected diameter was selected as 46 mm to incorporate safety margins, machining allowances, and to ensure performance under unexpected loading conditions.

##### Table 1. Motor Power vs. Shaft Parameters

| **Motor Power (HP)** | **Power (W)** | **Motor Torque (Nm)** | **Shaft Torque (Nmm)** | **Minimum Shaft Diameter (mm)** | **Final Shaft Diameter (mm)** |
| --- | --- | --- | --- | --- | --- |
| 0.5 | 373 | 2.47 | 98,941.32 | 21.3 | 26 |
| 1.0 | 746 | 4.95 | 197,882.65 | 26.8 | 32 |
| 2.0 | 1492 | 9.89 | 395,765.29 | 33.7 | 40 |
| 3.0 | 2238 | 14.84 | 593,647.94 | 38.6 | 46 |

A review of existing systems for processing biological waste such as cow dung indicates that augers with reduced pitch (less than the flight diameter) are frequently employed to enhance material compression and improve metering in high-resistance environments. Industry standards classify pitch size relative to flight diameter OD; for instance, short pitch is defined as approximately 2/3D, and reduced-pitch configurations like 0.4D (60 mm for a 150 mm flight) have been shown to increase conveying efficiency on inclines and during compression tasks Based on these insights, a 60 mm pitch was selected. Additionally, a market survey of commercial dewatering equipment supports the use of augers with diameters up to 152.4 mm and lengths of 300–400 mm, confirming that our chosen dimensions align with established industry practice. The following parameters were compared across configurations during design selection:

##### Table 2. Screw Press Design Parameters Derived from Motor Selection

| **Motor Power (HP)** | **Screw Press OD (mm)** | **Screw Pitch (mm)** | **Screw Length (mm)** | **Force by Screw (N)** | **Slurry Pressure (**N/**)** |
| --- | --- | --- | --- | --- | --- |
| 0.5 | 152 | 60 | 300 | 51,805.56 | 4.92 |
| 1.0 | 152 | 60 | 300 | 103,611.1 | 9.84 |
| 2.0 | 152 | 60 | 300 | 207,222.2 | 19.69 |
| 3.0 | 152 | 60 | 300 | 310,833.3 | 29.53 |

#### 2.2.2 SELECTION OF FILTER ELEMENT

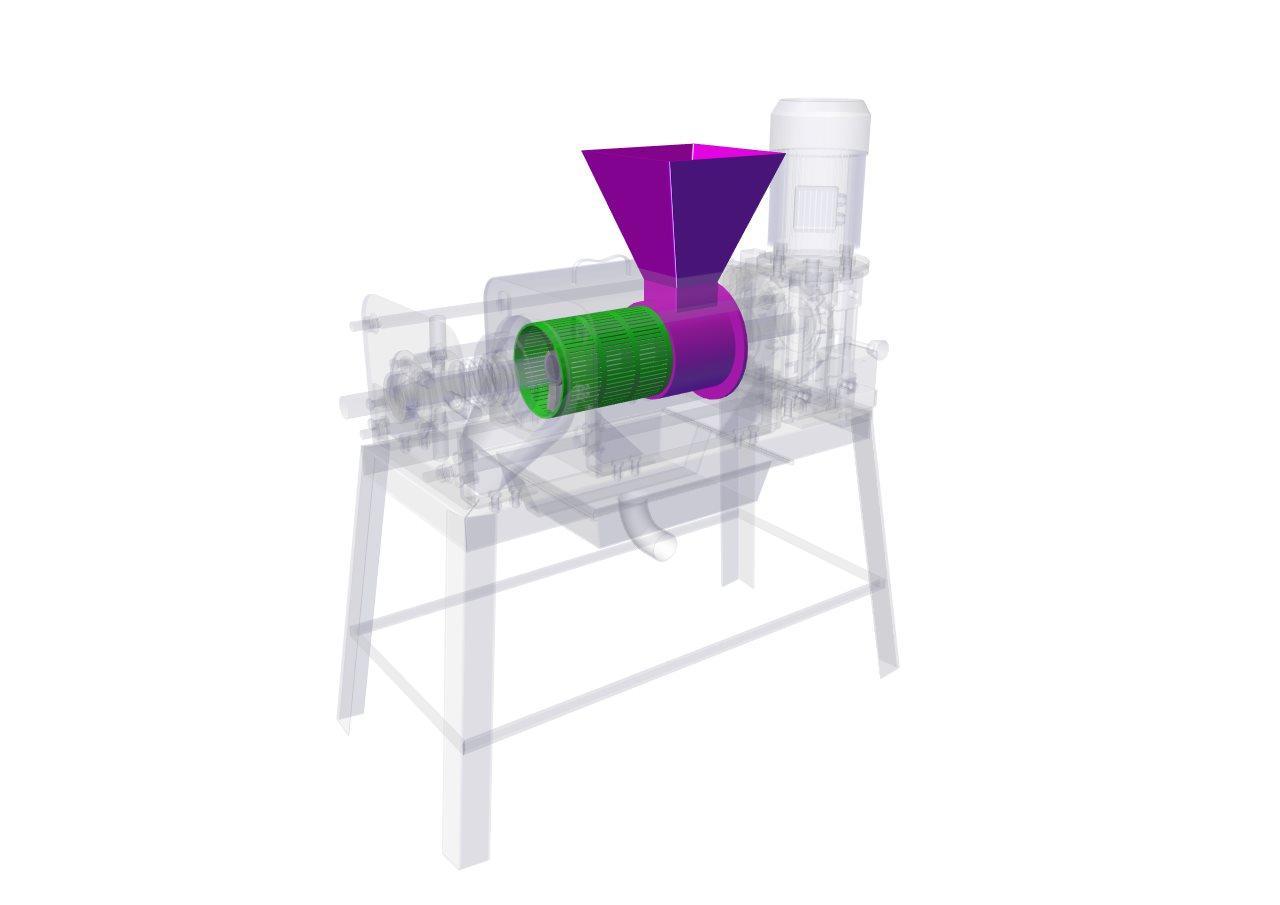
The performance of the screw-press dewatering system was evaluated using three mesh filter sizes 0.5 mm, 1.0 mm, and 1.5 mm under cow dung slurry-to-water feed ratios of 0.5:1, 1:1, and 2:1, achieved by mixing 5 kg of cow dung with 10 L, 5 L, and 2.5 L of water, respectively. Prior to performance evaluation trials, a laboratory survey of commercially available manure separators confirmed that slot sizes typically range from 0.3 mm to 3.0 mm, as offered by leading screw-press manufacturers.

Fig 3: filter assembly.

A laboratory-scale, manually operated hydraulic filter press rig was set up for testing the filters. The setup had a centrally mounted bottle-type hydraulic jack equipped with a lever and pressure gauge to apply controlled vertical pressure. The jack acted on a movable upper bed guided by vertical columns and supported by coil springs, ensuring uniform compression. The perforated filters of different sizes were typically placed between the upper and middle beds and pressure required was applied. These filters were tested in a laboratory setup to access their performance for further experiments. Filters with slit sizes ranging from 0.3 mm to 3 mm were tested, and based on performance, three optimal sizes—0.5 mm, 1.0 mm, and 1.5 mm—were selected for experimental analysis. This compact rig is ideal for evaluating slurry dewatering efficiency and filter media behaviour under controlled laboratory conditions.

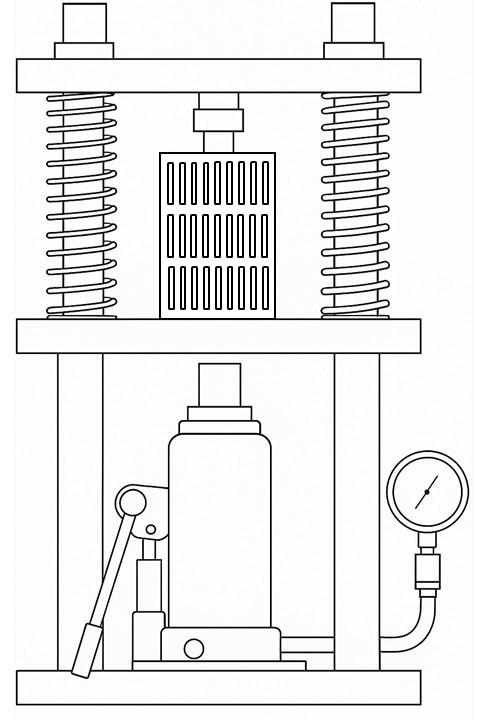


Fig 4: Manual Hydraulic Filter Press Rig – Lab Scale.

**2.2.3 PRESSURE PLATE ASSEMBLY**

A spring-loaded pressure plate was used to regulate the outlet resistance, ensuring sufficient compression of solids before discharge. The pressure plate was mounted concentrically at the auger outlet and pressed against the block pressure plate using a compression spring. Preload

adjustment was provided via a handle block mechanism incorporating four radial pins for manual turning and thread tightening. This enabled fine-tuning of the outlet gap without the need for additional tools. This setup allowed manual control of the final moisture content in the discharged solids without requiring hydraulic or electronic actuation. The design maintained structural simplicity while ensuring operational flexibility and consistent dewatering performance under variable feed conditions.

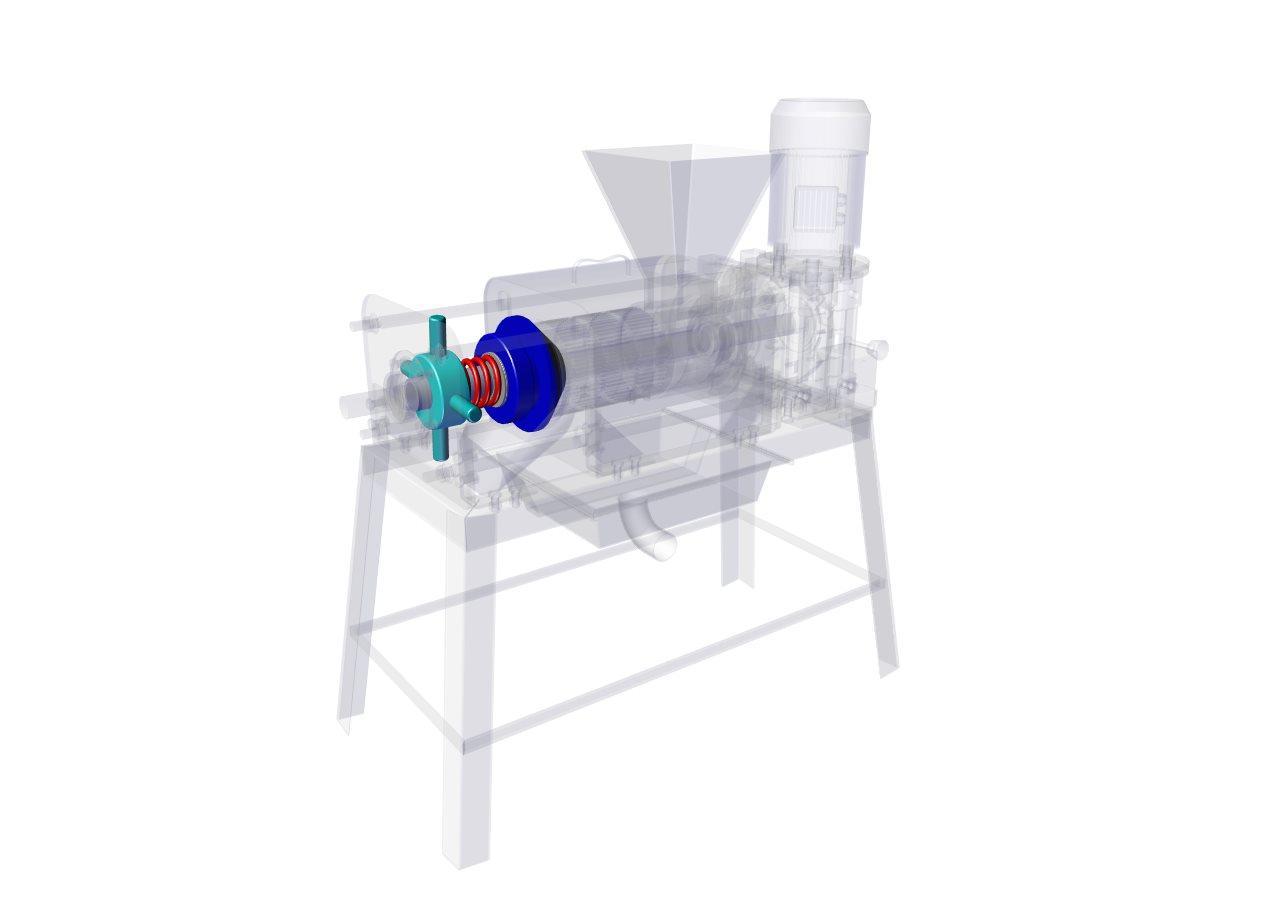


Fig: 5: Pressure plate assembly.

Based on system pressure and space constraints, the spring dimensions were selected to balance compressive force and manual adjustability. The recommended spring had an outer diameter of 100 mm, wire diameter of 10 mm, and free length between 150 mm and 200 mm. The spring consisted of 3 active coils and a stiffness of approximately 150–250 N/mm. These parameters ensured sufficient axial force application while maintaining compatibility with the screw auger housing and allowing field-level adjustment without tools.

### 2.3 FABRICATION

The prototype was constructed using mild steel framing and incorporated a 3 HP single-phase induction motor operating at 1440 rpm. Power was transmitted through a 1:40 worm gearbox, effectively reducing the shaft speed to 36 rpm, a necessary condition for achieving progressive material compression within the screw press. The motor was mounted on a dedicated pedestal, secured to block plates which were bolted to the main frame. This ensured mechanical stability and precise alignment. A keyed shaft interface connected the gearbox output to a single screw auger, transmitting torque efficiently for dewatering operations.

The shaft was fabricated from high-strength mild steel, selected for its mechanical integrity under torsional and axial loads. It was supported at both ends using tapered roller bearings: a 50 mm ID × 90 mm OD × 24.75 mm bearing at the drive-end for combined radial and thrust loads, and a 35 mm ID × 72 mm OD × 24.25 mm bearing at the free-end to ensure axial stability. A 55 mm ID × 90 mm OD × 16 mm thrust bearing was positioned within the compression block to counter axial loads generated during auger operation. Shaft collars were used to prevent lateral displacement, and machined slots helped maintain shaft alignment.

At the outlet end, a spring-loaded pressure plate was installed to regulate backpressure, ensuring only adequately compacted solids were discharged. A threaded tensioner allowed manual preload adjustments to control the moisture content of the output. Positioned between the inlet and compression zones, a monolithic filter plate with 0.5 mm slits enabled the effective separation of the liquid fraction. Beneath the filter, dedicated drainage channels were incorporated to facilitate efficient slurry removal. All rotating components were housed within oil-lubricated bearing enclosures to prevent slurry ingress and ensure long-term durability under both batch and continuous operation modes.

The inlet housing incorporated the primary slurry channel and a removable filter screen seated within grooved slots, allowing for easy removal and cleaning. A pressure plate at the outlet was spring-loaded, using an Ø100 mm helical compression spring (10 mm wire diameter, 100–200 mm free length, stiffness 200 N/mm). Tension was adjusted manually via a threaded block with four radial pins. All major components including the inlet and outlet blocks, pressure plate, auger, housing, and support stands were fabricated from mild steel, welded and aligned on a compact 1.2 × 0.6 × 1.2 m (L × W × H) frame. The complete assembly weighed under 110 kg, and its design prioritized ease of alignment, disassembly, repair, and servicing using basic hand tools, making it especially suitable for deployment in rural settings.

### 2.4 PERFORMANCE EVALUATION

Performance evaluation was conducted using fresh cow dung with an initial moisture content of 82–85%. Moisture reduction was measured using oven-drying (AOAC Method). Additional parameters included throughput, energy use, structural stability, and ease of maintenance. Multiple test cycles confirmed consistency and viability under rural conditions.

##### Table 3. Complete Experimental Matrix: Filter Performance by Slurry Ratio

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Dung: Water Ratio** | **Cow Dung (kg)** | **Water Added (kg)** | **Total Slurry Mass (kg)** | **Filter Size (mm)** | **Time Taken (min)** | **Liquid Extracted (L)** | **Solid Mass (kg)** |
| S1F1R1 | 0.5:1 | 10 | 20 | 30 | 0.5 | 16.56 | 27.19 | 2.81 |
| S1F1R2 | 0.5:1 | 10 | 20 | 30 | 0.5 | 16.21 | 27.33 | 2.67 |
| S1F1R3 | 0.5:1 | 10 | 20 | 30 | 0.5 | 16.38 | 27.28 | 2.72 |
| S2F1R1 | 1:1 | 10 | 10 | 20 | 0.5 | 14.12 | 17.09 | 2.91 |
| S2F1R2 | 1:1 | 10 | 10 | 20 | 0.5 | 14.28 | 17.11 | 2.89 |
| S2F1R3 | 1:1 | 10 | 10 | 20 | 0.5 | 14.37 | 17.04 | 2.96 |
| S3F1R1 | 2:1 | 10 | 5 | 15 | 0.5 | 14.59 | 12.26 | 2.74 |
| S3F1R2 | 2:1 | 10 | 5 | 15 | 0.5 | 14.51 | 12.36 | 2.64 |
| S3F1R3 | 2:1 | 10 | 5 | 15 | 0.5 | 14.31 | 12.32 | 2.68 |
| S1F2R1 | 0.5:1 | 10 | 20 | 30 | 1 | 13.46 | 27.62 | 2.38 |
| S1F2R2 | 0.5:1 | 10 | 20 | 30 | 1 | 13.53 | 27.6 | 2.4 |
| S1F2R3 | 0.5:1 | 10 | 20 | 30 | 1 | 13.12 | 27.68 | 2.32 |
| S2F2R1 | 1:1 | 10 | 10 | 20 | 1 | 11.43 | 17.42 | 2.58 |
| S2F2R2 | 1:1 | 10 | 10 | 20 | 1 | 11.00 | 17.4 | 2.6 |
| S2F2R3 | 1:1 | 10 | 10 | 20 | 1 | 11.10 | 17.48 | 2.52 |
| S3F2R1 | 2:1 | 10 | 5 | 15 | 1 | 10.58 | 12.54 | 2.46 |
| S3F2R2 | 2:1 | 10 | 5 | 15 | 1 | 11.00 | 12.48 | 2.52 |
| S3F2R3 | 2:1 | 10 | 5 | 15 | 1 | 10.43 | 12.52 | 2.48 |
| S1F3R1 | 0.5:1 | 10 | 20 | 30 | 1.5 | 9.32 | 27.9 | 2.1 |
| S1F3R2 | 0.5:1 | 10 | 20 | 30 | 1.5 | 9.14 | 28.17 | 1.83 |
| S1F3R3 | 0.5:1 | 10 | 20 | 30 | 1.5 | 8.52 | 28.02 | 1.98 |
| S2F3R1 | 1:1 | 10 | 10 | 20 | 1.5 | 7.28 | 17.72 | 2.28 |
| S2F3R2 | 1:1 | 10 | 10 | 20 | 1.5 | 7.33 | 17.86 | 2.14 |
| S2F3R3 | 1:1 | 10 | 10 | 20 | 1.5 | 7.41 | 17.81 | 2.19 |
| S3F3R1 | 2:1 | 10 | 5 | 15 | 1.5 | 7.28 | 13.06 | 1.94 |
| S3F3R2 | 2:1 | 10 | 5 | 15 | 1.5 | 6.39 | 13.13 | 1.87 |
| S3F3R3 | 2:1 | 10 | 5 | 15 | 1.5 | 6.44 | 13.02 | 1.98 |

S- slurry ratios (S1- 0.5:1, S2- 1:1, S3-2:1) F- Filter size (F1- 0.5 mm, F2- 1 mm, F3- 1.5 mm)

Experimental trials were conducted across all combinations of slurry-to-water ratios and filter meshes. The 1:1 slurry ratio consistently outperformed other, delivering faster dewatering and higher solid mass recovery particularly when paired with a 0.5 mm filter mesh. In contrast, the 0.5:1 ratio caused over-dilution and protracted processing times, while the 2:1 ratio limited liquid output due to reduced water content and required more time for extraction – particularly when considering volume f) owing to its higher viscosity.

A two-way ANOVA confirmed the statistical significance of both variables: slurry consistency (F = 27.57, p < 0.0001) and filter fineness (F = 286.50, p < 0.0001) with no significant interaction detected (p = 0.103), indicating independent contributions to performance. These findings justify the choice of the 0.5 mm mesh with a 1:1 feed ratio for the final design, as this combination optimally balances throughput and separation efficiency for small-scale manure-handling systems.

Experimental data collected across few trials showed that the 0.5 mm filter produced the best overall performance in terms of liquid extracted per unit of time. Across three feed ratios and three slurry batches, 0.5 mm filters consistently yielded the highest average solid extraction (2.78 kg), outperforming both 1.0 mm (2.47 kg) and 1.5 mm (2.03 kg) slit sizes.

## 3. RESULTS AND DISCUSSION

The cow dung dewatering machine was evaluated for torque generation, dewatering performance, and mechanical stability under practical smallholder conditions. The 3 HP motor, coupled with a 1:40 reduction gearbox, delivered sufficient torque (593,648 Nmm) to rotate the auger at 36 rpm. This enabled continuous compression of high-moisture cow dung without motor overload or structural vibration.

The measured throughput and moisture reduction performance aligned with findings from Bhandari & Kumar (2020) and Amon et al. (2006), affirming suitability for decentralized manure treatment. Observations on slurry flow dynamics matched screw press models developed by Egenes et al. (2019).

Samples were taken for treatment and dewatered using the hot-air oven method. Field trials on raw cow dung, with initial moisture content of 82–85 %, consistently reduced the output moisture 49.6%. An adjustable pressure plate enabled fine-tuning of the moisture level via spring preload, making the system well-suited for small-scale farm operation. The dewatered solids were then oven-dried to ensure stable final moisture levels.

The liquid extracted through the 0.5 mm filter was nutrient-rich, free-flowing, and nearly free of suspended solids, with no clogs or leaks during extended operation. The solid fraction remained intact and ready for composting or vermiculture without further drying. Mechanically, the system ran quietly with stable bearings and intact oil seals, preventing slurry entry. All steel joints and the shaft-bearing arrangement held firm, confirming the design’s robustness. These results show the system meets performance expectations for decentralized cow-dung management in smallholder settings.

## 4. CONCLUSION

The developed screw auger-based cow dung dewatering system met the design intent by reducing slurry moisture content and improving handling efficiency on smallholder farms. Using a 3 HP motor and a constant-pitch auger mechanism, the machine consistently achieved effective solid-liquid separation, minimizing mechanical complexity and cost. Trials verified moisture reduction to 49.6% and throughput rates of up to 220 kg/h. No clogging or bearing wear was observed across continuous 2-hour trials using fresh cow dung at 82–85% initial moisture.

The integration of a 0.5 mm slit filter and an adjustable spring-loaded pressure plate enabled effective control over dryness and throughput. The system was built on a compact 1.2 × 0.6 x 1.2 m (L x W x H) frame, ensuring portability and ease of deployment in constrained farm environments. Locally sourced materials and modular fabrication methods further enhanced field maintainability. Overall, the system offers a viable manure management solution suited to small-scale agricultural operations.

## ETHICAL APPROVAL

This study did not involve any human or animal subjects. All data collected were obtained through mechanical testing of agricultural waste with informed consent from participating farm owners.

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