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Design and Development of a Trash and Oil Trap for Drainage in Commercial Area Using Waste Chicken Feathers

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ABSTRACT

This study presents the design and development of a trash and oil trap system for drainage in commercial areas. The trap incorporates chicken feather waste as an absorbent medium to capture used oil, in addition to trapping solid trash. The research addresses the limitations of conventional trash traps, which are typically effective only for solid waste. Using customer input, benchmarking of existing products, and prototype testing, a final design was fabricated and analyzed. Results demonstrated that the chicken feather sorbent achieved an oil absorption capacity of 474 g, showing promise as an effective, low-cost, and environmentally friendly approach to reduce drainage pollution in commercial areas. In addition to environmental benefits, the design also provides ergonomic advantages by reducing the manual workload and repetitive cleaning tasks of maintenance workers, thereby minimizing strain and improving overall efficiency. The proposed design offers a practical solution for improving drainage maintenance in commercial areas while promoting sustainability through the utilization of poultry waste.

Keywords: Chicken Feather, Drainage, Oil Absorption, Oil Trap

1. INTRODUCTION

Commercial areas such as workshops, restaurants, food courts, wet markets and food-processing outlets generate large quantities of wastewater containing oil and solid trash. When discharged into drainage systems without proper handling, these contaminants can accumulate along pipe walls, restrict water flow, and cause blockages that lead to costly maintenance and environmental pollution. The presence of oil in drainage networks also reduces dissolved oxygen levels, disrupts aquatic ecosystems, and increases health risks due to foul odour and pathogen growth like bacteria, viruses, and fungi, which can cause disease. Conventional oil traps are widely used to address these issues; however, they often face limitations, including high installation costs, frequent maintenance requirements, unpleasant odour buildup, and poor retention of floating micro-oil droplets. These limitations highlight the need for alternative and sustainable solutions capable of effectively removing trash and oil contaminants simultaneously.

In parallel, the poultry industry continues to grow globally, generating millions of tonnes of chicken feather waste each year. Chicken feathers constitute approximately 5–7% of the total live weight of a chicken, and their disposal represents a serious environmental challenge. In many countries, feather waste is commonly dumped in landfills, burnt, or processed into low-value products. Cheong et al. reported that Malaysia alone generated around 43,000 tonnes of feather waste in 2016, yet only a very small fraction is converted into value added products [1]. Globally, the continued expansion of poultry production further intensifies disposal concerns, contributing to greenhouse gas emissions, odour, and land pollution when feathers are not properly managed.

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As a result, promoting chicken feather waste into functional materials aligns strongly with sustainable development practices.

Recent studies have demonstrated that chicken feathers possess intrinsic physicochemical properties that make them highly suitable for oil-adsorption applications [1]. Structurally, feathers consist of a central rachis with a hierarchical arrangement of barbs and barbules, creating a lightweight and highly porous structure. This morphology provides large surface area and abundant binding sites for oil droplets. Chemically, the keratin matrix is rich in hydrophobic amino acids and stabilized by disulfide cross-links and hydrogen bonds, resulting in a material that is naturally hydrophobic and oleophilic. These properties favour the selective sorption of oil while repelling water, constituting a critical requirement for the efficient separation of oil and water.

Okoya et al. found that pulverized chicken feather waste achieved oil-removal efficiencies up to 99.95% under optimized conditions, surpassing even commercial activated carbon in some cases [2]. The authors concluded that chicken feathers are an efficient, low-cost and environmentally friendly sorbent for removing crude oil from contaminated water. Similarly, Strnad et al. evaluated various feather based absorbent forms, including loose fibres, feather filled pillows and composite sheets, and reported that loose feathers exhibited the highest oil absorption capacity due to their open fibrous structure [3]. This highlights the importance of maintaining feather morphology when designing sorbent systems.

More advanced valorization approaches, such as regenerated keratin sponges, have also shown promising performance. Sadeghi et al. produced porous keratin-based sponges from waste chicken feathers and demonstrated excellent oil uptake, high porosity and good mechanical stability during repeated adsorption–desorption cycles [4]. These findings indicate that chicken-feather–derived keratin can be engineered into different material forms depending on the needs of a specific application.

In addition to sorption capacity, the surface energetics of feather fibres further support their suitability as oil sorbents. Using contact-angle analysis and surface-energy modelling, Chinwah et al. showed that chicken feather mats have low surface free energy and strong dispersive components, enabling hydrocarbons to wet the surface easily while limiting water penetration [5]. This oleophilic behaviour enhances the ability of feather materials to selectively adsorb oil droplets even in the presence of flowing water, which is an essential feature for drainage environments.

Beyond adsorption-based removal, feathers have also been processed into dispersants for oil pollution control. Adofo et al. developed a chicken feather protein (CFP) dispersant that achieved dispersion effectiveness of up to 69% in marine environments and was found to be practically non-toxic to aquatic organisms [6]. Although this application differs from physical oil trapping, it demonstrates the versatility of feather derived keratin as a functional biopolymer.

Despite numerous studies confirming the oil adsorption capability of chicken feathers, research remains limited in applying feather-based sorbents within functional drainage systems, particularly those in commercial areas where trash, solids, oils and grease coexist. Most existing work focuses on controlled laboratory tests or marine oil-spill treatment. Drainage systems, however, present a more complex environment involving variable flow rates, mixed waste compositions, high trash loads and a higher risk of clogging. Therefore, there is a clear research gap in translating feather-based sorbent materials into a practical oil trap device capable of retaining both floating trash and oil in real drainage applications.

This study aims to address this gap by designing and developing a trash and oil trap system that incorporates waste chicken feathers as the core oil adsorbent material. The proposed system is

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intended for use in commercial drainage environments, where food residues, plastics and used oils are commonly discharged. By integrating feather fibres into a modular filter cartridge or mat within the trap, the system can take advantage of feathers' high oil-adsorption capacity, low cost and natural abundance. The anticipated benefits include improved retention of floating oils, reduced grease buildup, lower maintenance frequency and enhanced environmental sustainability through the recycling of agricultural waste.

Overall, this research not only provides a novel engineering application for chicken feather waste but also contributes to ongoing efforts in green technology, waste minimization and sustainable water management. The development of a feather-based trash and oil trap system presents a practical pathway to reduce environmental pollution in commercial drainage systems while concurrently utilizing an abundant biological waste resource for beneficial purposes.

2. METHODOLOGY

The methodology of this study involved a structured approach beginning with data collection through a user survey to identify common drainage issues, user expectations, and functional requirements for an improved trap design. These customer needs were translated into measurable engineering metrics and used to guide product development. Benchmarking of existing trash traps and oil-management systems was conducted to identify performance gaps and potential features for integration. Four initial design concepts were generated and systematically evaluated using concept screening and scoring techniques to select the most promising elements for further refinement. The final prototype was fabricated using lightweight materials with dedicated compartments for chicken feather sorbents, followed by functional, performance, and durability testing to assess its ability to capture trash and absorb oil under simulated drainage conditions. Ergonomic considerations were incorporated throughout the design and evaluation stages to ensure safe handling, ease of maintenance, and suitability for real-world commercial environments.

2.1 Data Collection

To identify user requirements and preferences, a survey was conducted. Participants comprised local council workers and residents living near commercial areas. The survey examined issues related to drainage pollution, user awareness of trash traps, and expectations for improved designs.

The survey findings indicated that 72% of respondents had observed pollution within their commercial areas, with 65% identifying both trash and oil as the primary contributors. Furthermore, 93% of respondents expressed support for enhancing trash trap systems through the incorporation of oil absorbing features.

2.2 Product Development

The product development process followed a systematic approach beginning with the identification and prioritization of customer requirements. Feedback gathered from users highlighted the need for a drainage trap that is functional, lightweight, easy to maintain, durable, and competitively priced while incorporating environmentally sustainable features. These requirements were then translated into the engineering metrics presented in Table 1, namely the type of materials used, overall weight, operational efficiency, maintenance needs, size, and price. Each metric served as a measurable benchmark to guide decision-making throughout the concept generation, material selection, and prototype refinement stages. By establishing clear quantitative and qualitative performance indicators, the development process ensured that the

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final design addressed user expectations while meeting technical, ergonomic, and sustainability criteria.

Benchmarking was carried out by reviewing existing solutions such as storm netting trash traps, Bandalong litter traps, bio-cleaner systems, floating booms, and autonomous river-cleaning robots. While these products demonstrated effectiveness in trapping solid waste, none adequately addressed liquid oil contamination. This gap highlighted the potential impact of incorporating chicken feather as a sorbent material to trap oil.

Table 1. Engineering Metrics Used in the Product Development Process.

Engineering Metric	Description and Measurement Criteria
Type of Materials Used	Selection of materials based on strength, durability, corrosion resistance, environmental sustainability, and suitability for prolonged exposure to drainage conditions.
Weight	Total mass of the device, emphasizing lightweight construction to enhance ease of handling, installation, and maintenance.
Efficiency	Ability of the trap to perform its intended functions, including effective trash capture and oil absorption using chicken-feather sorbents.
Maintenance	Frequency, ease, and safety of routine cleaning and component replacement, assessed through modularity and accessibility of internal parts.
Size	Overall dimensions of the trap to ensure compatibility with drainage channels, adequate buoyancy, and sufficient capacity for trash and sorbent storage.
Price	Cost-effectiveness of the design, considering material expenses, fabrication processes, and affordability for widespread implementation in commercial settings.

2.3 Concept Generation

Through the concept generation process, four preliminary design options were developed. Each concept was systematically evaluated and scored according to its potential to fulfil both customer requirements and technical specifications. The assessment criteria included design functionality, structural integrity, safety, and ease of maintenance.

The four preliminary concepts differed in casing geometry, material selection, and buoyancy mechanisms. Concept 1 (Figure 1) employed ABS plastic in a simple configuration but demonstrated limited long-term durability. Concept 2 (Figure 2) incorporated a rectangular buoy design constructed from fiberglass and polystyrene, which enhanced structural strength but introduced risks of tube damage. Concept 3 (Figure 3) employed a cylindrical casing made of fiberglass and ABS, providing weight reduction but demonstrating fragility. Concept 4 (Figure 4) featured a cube-shaped structure with PVC pipes for flotation, which proved effective yet constrained feather storage capacity. Concepts 2 and 4 were subsequently refined, with selected elements from both integrated into the final prototype.

Each concept was systematically evaluated and scored according to its potential to satisfy customer requirements and technical specifications, employing concept screening (Table 2) and concept scoring (Table 3). Concepts 2 and 4 achieved the highest scores and were subsequently refined into the final prototype.

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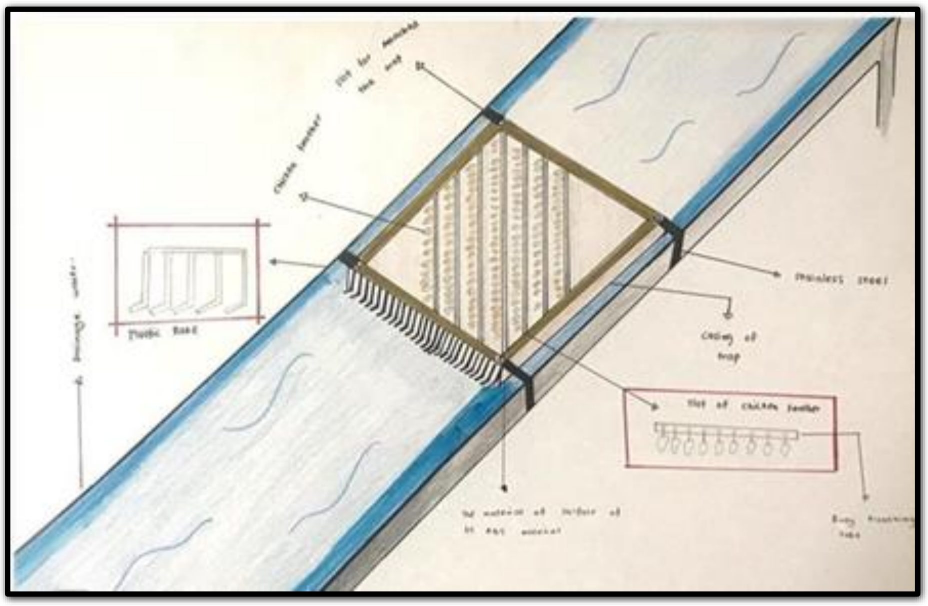

Figure 1. Design Concept 1.

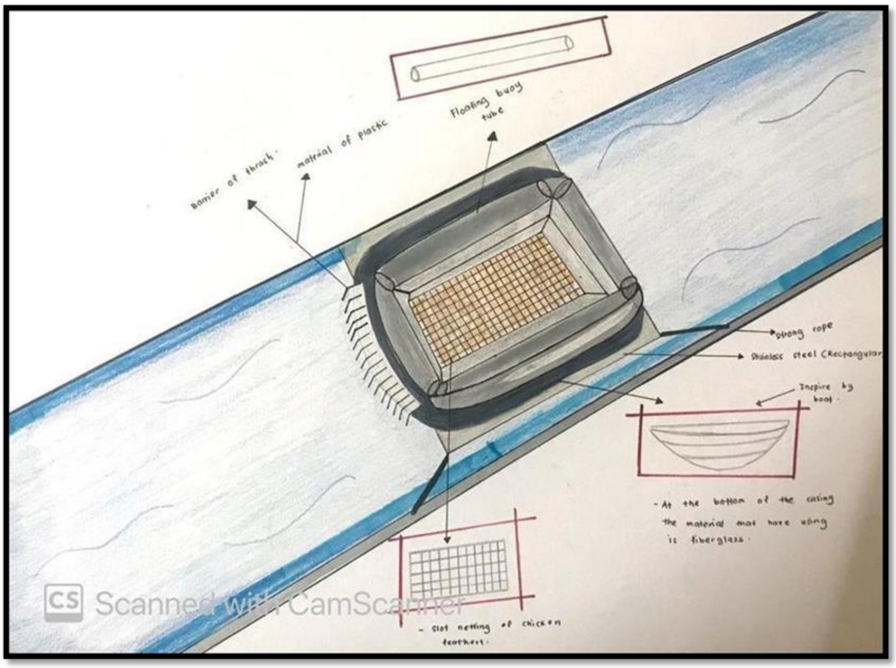

Figure 2. Design Concept 2.

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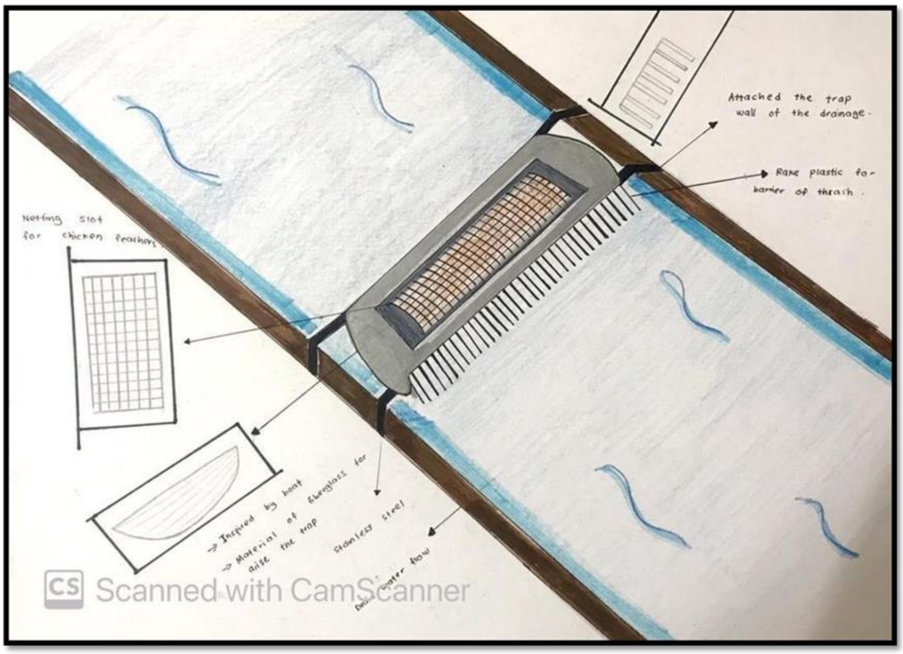

Figure 3. Design Concept 3.

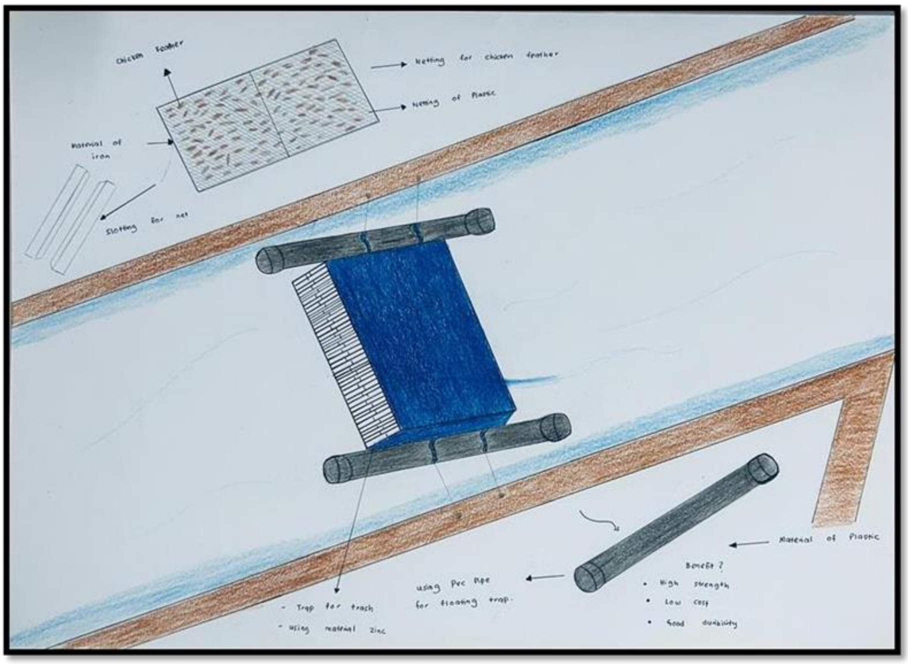

Figure 4. Design Concept 4.

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Table 2. Concept Screening.

Need Statement	Concepts				
	1	2	(Reference)	3	4
Duration of the process	-	+	0	0	+
Functionality	-	+	0	+	+
Design	+	+	0	-	+
Material quality	0	-	0	0	-
Safe to use	0	0	0	0	+
Affordable price	0	0	0	0	0
Flexibility of sizing	-	-	0	-	0
Sum of '+'	1	3	0	1	4
Sum of '-'	3	2	0	2	2
Sum of '0'	3	2	7	4	2
Total	-2	1	0	-1	2
Rank	4	2	5	3	1
Continue?	No	Yes	Yes	No	Yes

Concept Scoring(+) - "better than" (-) - "worse than" (0 - "same as"

Table 3. Concept Scoring.

Selection Criteria	Concept				
	Weightage	Concept 2		Concept 4	
		Rating	Weighted score	Rating	Weighted score
Duration of the process	17%	4	0.68	4	0.68
Functionality	17%	5	0.85	5	0.85
Design	17%	4	0.68	5	0.85
Material quality	14%	3	0.42	4	0.56
Safe to use	14%	4	0.56	4	0.56
Affordable price	10%	3	0.3	3	0.3
Flexibility of sizing	10%	3	0.3	2	0.2
Total score			3.76		4.00
Rank			2		1
Continue?			Develop		Yes

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2.4 Prototype Fabrication

The final prototype incorporated a buoyant structure, trash net barriers, and compartments filled with chicken feathers for oil absorption. The design prioritized simplicity, affordability, and ease of maintenance. The use of PVC pipes and lightweight materials enhanced buoyancy and handling, while the modular feather compartments enabled straightforward replacement and cleaning. An exploded view and a rendering of the final design are presented in Figures 5 and 6, respectively.

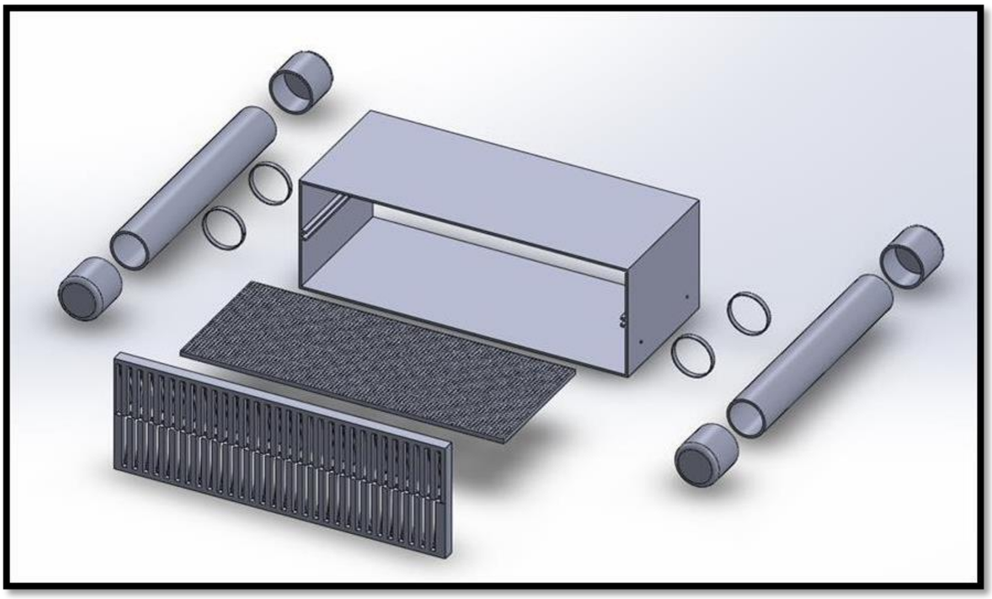

Figure 5. Exploded View of trash and oil trap.

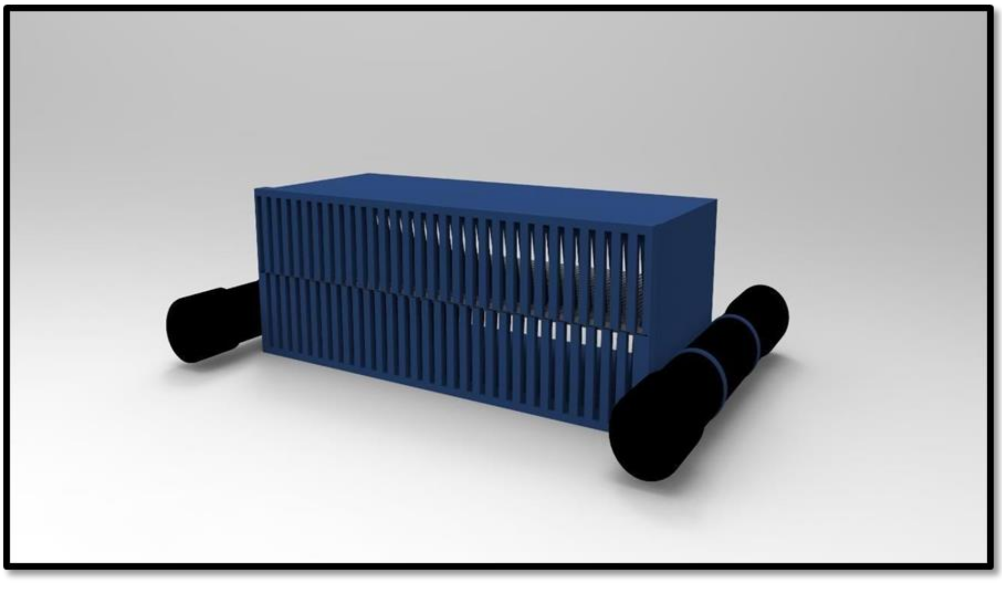

Figure 6. Rendering of trash and oil trap oil.

The final prototype was fabricated using ABS plastic, fiberglass, and PVC pipes, with compartments filled with chicken feathers serving as the sorbent. The fabrication process involved cutting, painting, assembly, and the integration of buoyancy mechanisms to ensure stable flotation in drainage water. The final assembled prototype is presented in Figure 7.

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Figure 7. The final assembled prototype.

2.5 Testing for Functionality

Testing of the prototype included functional and durability assessments. Functional testing evaluated the trap's ability to capture both trash and oil (Figure 8). Performance testing measured the oil absorption capacity of the chicken feathers, while durability testing examined the resilience of the trap under drainage conditions. To determine absorption capacity, 1 kg of used oil was poured into the drainage system. The weight of the netting containing dried chicken feathers (Figure 9) was recorded before and after testing. The netting was kept dry prior to recording its weight after the test.

Figure 8. Functional testing of Prototype.

Figure 9. The dried chicken feather was kept in nylon mesh netting.

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3. RESULTS AND DISCUSSION

The findings of this study highlight both the functional performance of the developed trash and oil trap and its practicality for use in commercial drainage environments. Prototype testing demonstrated that the system effectively captured solid waste while achieving substantial oil absorption using chicken feather sorbents, with stable operation observed under varying flow conditions. In addition to its technical capability, the design incorporates key ergonomic features such as lightweight materials, modular components, and simplified maintenance steps that reduce physical effort, minimize strain, and improve safety during routine handling and cleaning tasks. Collectively, these results indicate that the proposed design offers a robust, user-friendly, and sustainable solution for managing trash and oil contamination in drainage systems.

3.1 Prototype Testing

Functional testing confirmed that the prototype could effectively capture both solid trash and oil. Performance testing demonstrated that the chicken feathers achieved an oil absorption capacity of 474 g. Based on the 1kg oil used for testing this is equivalent to 47.4% of effectiveness. The weight of chicken feather before and after oil testing is shown in Table 4.

Table 4. Weight of chicken feathers before and after oil testing.

Weight of chicken feather including mesh features **before** experiment	Weight of chicken feather including mesh features **after** experiment
493 grams	967 grams

Testing also showed that the prototype was able to maintain performance under simulated drainage conditions, including exposure to heavy water flow and accumulated debris. Compared to existing traps, the developed prototype demonstrated superior performance by addressing both solid and liquid waste simultaneously. While current designs are limited to capturing floating trash. The integration of chicken feather sorbents successfully extended the trap's functionality to oil absorption, offering a more comprehensive solution for drainage pollution in commercial areas.

3.2 Ergonomic Considerations

The design and development of the trash and oil trap emphasized ergonomic principles to ensure safe, efficient, and user-friendly operation during installation, routine maintenance, and waste handling tasks. In commercial drainage environments, maintenance workers are frequently exposed to awkward postures, repetitive movements, excessive bending, and prolonged contact with contaminated waste. These factors can contribute to musculoskeletal strain and increase the risk of work-related injuries. Therefore, incorporating ergonomic features into the prototype was a key design priority.

Firstly, the selection of lightweight materials such as PVC pipes, ABS plastic, and fiberglass significantly reduced the overall mass of the trap, enabling workers to lift, transport, and position the system with minimal physical effort. This reduction in load directly minimizes potential strain on the lower back, shoulders, and upper limbs, supporting safe manual-handling practices. The buoyant components were also designed to stabilize the device in water, preventing sudden shifts that could otherwise complicate retrieval or repositioning tasks.

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Secondly, the prototype incorporates a modular design consisting of detachable compartments for chicken feathers and trash collection. This modularity enables maintenance personnel to remove and replace the sorbent casings without dismantling the entire structure. From an ergonomic perspective, this approach reduces maintenance time, eliminates unnecessary repetitive tasks, and allows cleaning activities to be performed at waist height rather than requiring workers to reach deep into drainage systems. Such features promote neutral postures and reduce the risk of cumulative strain injuries.

Additionally, the arrangement of the trash net and oil-absorbing compartments was designed to ensure easy access and clear visibility of internal components. This helps workers identify when the feathers are saturated or when trash accumulation reaches its threshold, thereby preventing overexertion caused by infrequent maintenance or excessive force during cleaning. The choice of materials also supports hygienic handling by reducing direct contact with contaminated waste, which enhances user safety and minimizes exposure-related hazards.

Finally, the overall maintenance workflow was evaluated to ensure compatibility with existing municipal or commercial cleaning procedures. By simplifying the steps required to empty the trap, replace feathers, and reinstall the device, the design reduces cognitive workload and physical fatigue. These ergonomic improvements contribute to higher operational efficiency, reduced downtime, and improved worker well-being during sustained use in real drainage environments.

Overall, the integration of ergonomic considerations into the prototype design enhances usability, safety, and maintenance efficiency, making the system suitable for long-term application in commercial drainage management.

4. CONCLUSION

This study successfully developed a trash and oil trap system that addresses the limitations of conventional drainage solutions in commercial environments. By integrating waste chicken feathers as a natural oil sorbent, the prototype demonstrated the ability to capture both solid debris and used oil, achieving an oil absorption of 474 g, which corresponds to 47.4% effectiveness relative to the 1 kg of oil introduced during testing. The design also exhibited stability under simulated drainage conditions and offered practical advantages through its lightweight construction, modular compartments, and simplified maintenance process. These features collectively reduce the physical workload of maintenance personnel and support safer and more efficient waste-handling practices. In addition to improving drainage cleanliness, the system promotes environmental sustainability by converting poultry waste into a functional and low-cost material. Future work may focus on enhancing material durability, validating long-term performance in real commercial settings, and exploring automated or replaceable sorbent modules to further improve operational efficiency. Overall, the findings demonstrate that the chicken-feather-based trapping method provides a promising pathway for mitigating drainage pollution while contributing to sustainable waste utilization.

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REFERENCES

[1] C. W. Cheong, Y. S. Lee, S. A. Ahmad, P. T. Ooi, and L. Y. Phang, "Chicken feather valorization by thermal alkaline pretreatment followed by enzymatic hydrolysis for protein-rich hydrolysate production," Waste Management, vol. 79, pp. 658–666, 2018, doi: 10.1016/j.wasman.2018.08.029.

[2] A. A. Okoya, N. O. Ochor, A. B. Akinyele, and O. O. Olaiya, "The use of chicken feather waste as an adsorbent for crude oil clean up from polluted water," Journal of Agriculture and Ecology Research International, vol. 21, no. 3, pp. 43–53, 2020, doi: 10.9734/JAERI/2020/v21i330136.

[3] S. Strnad, A. Jug, and Z. Peršin Fratnik, "Composite materials based on waste chicken feather fibers for oil-spill management," Journal of Natural Fibers, vol. 21, no. 1, Article 2346803, 2024, doi: 10.1080/15440478.2024.2346803.

[4] S. Sadeghi, F. Dadashian, and N. Eslahi, "Recycling chicken feathers to produce adsorbent porous keratin-based sponge," International Journal of Environmental Science and Technology, vol. 16, no. 2, pp. 1119–1128, 2019, doi: 10.1007/s13762-018-1669-z.

[5] K. Chinwah, S. Ahmed, M. Naderi, R. N. Okparanma, and C. R. Cheeseman, "Surface energetics and surface chemistry of chicken feather mat for oil spill cleanup application," Journal of Industrial and Engineering Chemistry, vol. 138, pp. 165–174, 2024, doi: 10.1016/j.jiec.2024.03.050.

[6] Y. K. Adofo et al., "Chicken feather protein dispersant for effective crude oil dispersion in the marine environment," ACS Omega, vol. 8, no. 38, pp. 34948–34958, 2023, doi: 10.1021/acsomega.3c04417.Antonio, M. (2002). *Trap for pollutants and solid trash*. United States Patent No. US20020011234A1.

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