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FROM PETALS TO PRODUCTS: CRAFTING SOAP, PAPER, INCENSE STICKS AND BIOFERTILIZER FROM FLORAL WASTE

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ABSTRACT
This research focused on the sustainable use of flower waste by developing four eco-friendly products: handmade paper, natural soap, biofertilizer, and natural incense made from marigold flowers (Tagetes erecta) and other floral materials. Marigold petals, often thrown away after festivals and religious events, were processed to create cellulose- rich pulp. The petals were treated with alkali, washed, blended, formed into sheets, and dried to make handmade paper. The paper was evaluated for fiber quality, color retention, texture, and mechanical strength. It showed good durability and improved visual appeal.

Natural flower-based soaps were made using the cold-process method. Aqueous or powdered extracts of marigold was added during saponification to provide natural fragrance, mild color, and antioxidant benefits. The soaps were tested for pH, foaming ability, skin compatibility, and storage stability.

Biofertilizer was produced from dried marigold flower waste through controlled burning. This created nutrient-rich ash with potassium, calcium, and trace minerals that enhance soil fertility. Natural incense sticks or cones were also made using powdered marigold petals mixed with natural binders and aromatic ingredients, resulting in biodegradable incense with a mild scent.

Overall, the study shows an effective circular bioeconomy approach to turning floral waste into valuable, low-cost, eco-friendly consumer products.

***Keywords**: Floral waste, Eco-friendly products, Biofertilizer, circular bioeconomy,Waste valorization , natural soap, handmade paper.*

1. INTRODUCTION
The global crisis of municipal solid waste (MSW) is acute in India, where organic matter constitutes 40%–50% of the total stream (Reddy et al., 2025). Much of this is generated by cultural and religious activities, with floral offerings totaling over 800 million tons annually (Jadhav et al., 2025). Due to their "sacred" status, these remains are often discarded into water bodies, causing severe pollution (Lamsal & Pun, 2025; Reddy et al., 2025). Furthermore, the improper decomposition of floral waste in landfills or rivers releases harmful greenhouse gases like CO_2, CH_4, and NH_3 (Lamsal & Pun, 2025; Reddy et al., 2025). Effectively addressing this challenge is vital for environmental conservation, aligning with approximately 60% of the UN Sustainable Development Goals (Reddy et al., 2025).

Current Research and the Knowledge Gap:
Research advocates for a "petals to products" transition to utilize the biochemical properties of floral remains. Botanical extracts can serve as natural substitutes for synthetic antibacterial agents like Triclocarban, which are linked to antibiotic resistance (Yardani et al., 2023). Studies show that floral extracts in soap help maintain a skin-neutral pH, essential for protecting the skin's lipid layer and preventing conditions like atopic dermatitis (Kupkina & Mozyrska, 2023; Yardani et al., 2023). Consequently, herbal soaps offer a natural solution for healthy skin, avoiding the irritation caused by synthetic alternatives (Ghonge et al., 2025; Mahesh et al., 2025).

Additionally, the controlled incineration of floral residues produces mineral-rich biomass ash; specifically, flower ash is exceptionally rich in potassium (K), making it a potent biofertilizer (Adderley et al., 2023; Reddy et al., 2025). Beyond chemical extractions, floral waste can be processed into cellulose-rich handmade paper or natural incense sticks using eco-friendly binders (Jadhav et al., 2025). However, while some studies explore municipal sludge as a soil amendment (Amrin Banu et al., 2025), there remains a critical need for an integrated valorization model that combines these disparate processes into a single, cohesive system.

Study Objective and Zero-Waste Framework:
This study focuses on Marigold (Tagetes erecta) to develop a "zero-waste" framework. The objective is to demonstrate how a single waste stream can be converted into an integrated suite of high-value assets: handmade

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paper, antioxidant-rich soap, natural incense, and nutrient-dense biofertilizer. Using laboratory methods—including maceration, pulping, and incineration—this research aims to prove the feasibility of a circular bioeconomy and provide a scalable solution to reduce pollution.

2. LITERATURE REVIEW

Solid waste management is a critical challenge in nations where a high percentage of municipal waste is biodegradable (Amrin Banu et al., 2025; Reddy et al., 2025). In India, marigold flowers (*Tagetes erecta*) comprise a significant portion of organic waste due to their use in religious ceremonies (Lamsal & Pun, 2025; Reddy et al., 2025). Improper disposal of these remains into water bodies leads to severe pollution and greenhouse gas emissions (Lamsal & Pun, 2025; Reddy et al., 2025).

The sustainable valorization of marigold waste aligns with circular economy principles. Research has shown that floral pulp can be processed into specialty handmade paper, offering an eco-friendly alternative to wood-based products (Jadhav et al., 2025). Additionally, marigold extracts are utilized in natural soaps for their antimicrobial properties, providing a skin-friendly substitute for synthetic chemicals (Mahesh et al., 2025; Yardani et al., 2023). These formulations help maintain skin health (Ghonge et al., 2025).

Thermal conversion of marigold waste into ash is another effective pathway. Incineration concentrates essential nutrients like potassium (K), creating a potent natural biofertilizer (Reddy et al., 2025). Studies indicate that such organic soil amendments enhance nutrient availability and promote plant growth (Adderley et al., 2023; Reddy et al., 2025). Furthermore, floral waste is used to manufacture incense sticks using natural binders (Jadhav et al., 2025). These products burn efficiently with lower soot emissions compared to synthetic versions (Jadhav et al., 2025). While these individual pathways show promise, there is a distinct need for an integrated "zero-waste" model (Amrin Banu et al., 2025; Reddy et al., 2025).

3. RESEARCH METHODOLOGY

Production of Handmade Paper:

100g marigold petals

Filter and wash pulp with distilled water

Blend pulp with 500ml distilled water into fine paste

Boil in 8% NaOH & sodium sulphate solution for 1 hour

Submerge sieve in water tray and add paste

Agitate to create uniform layer

Remove excess water with dry cloth

Air dry at room temperature

a. Collection of flower waste b. Flower pulp c. After sieve d. Paper sheet

Production of Biofertilizer Ash:

The production of bio fertilizer focused on the thermal conversion of floral remains into nutrient-rich ash. We incinerated 250g of dried floral waste in a controlled environment until it was reduced to a fine mineral residue. This

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ash serves as a potent source of potassium and calcium, which are essential for enhancing soil fertility (Reddy et al., 2025). To evaluate its effectiveness, a pot trial method was established using Vigna radiata (Moong Dal) seeds (Adderley et al., 2023). The experimental group was treated with a solution of dissolved ash water, while the control group received only distilled water. Growth parameters, including the germination rate by Day 3 and daily shoot height measurements in centimeters (cm), were recorded over a 7-day period. On Day 1, the plant treated with ash measured approximately 2.0 cm, while the plant without ash measured about 1.5 cm; on Day 3, the plant with ash reached around 5.5 cm compared to 3.5 cm without ash; and by Day 7, the plant with ash grew to approximately 10.0 cm, whereas the plant without ash reached about 6.5 cm.

Ash

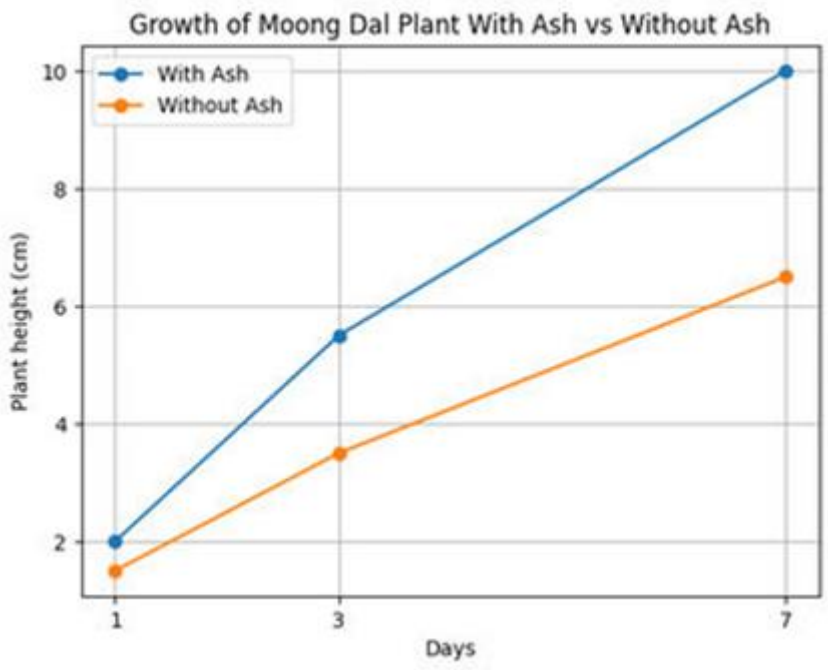
Dissolved Ash Water

Evaluating its growth on plant

DAY -1 GROWTH

DAY -3 GROWTH

DAY -7 GROWTH



COMPARISON GRAPH BETWEEN GROWTH OF PLANT WITH AND WITHOUT ASH

Formulation of Polyherbal Soap:

In the formulation of the polyherbal soap, we used a melt-and-pour technique to incorporate the marigold extracts. We took 200g of a glycerin soap base, sliced it into small pieces, and melted it using a double boiler until it reached a smooth, liquid consistency. Once melted, we added 50g (which is a 10% concentration) of

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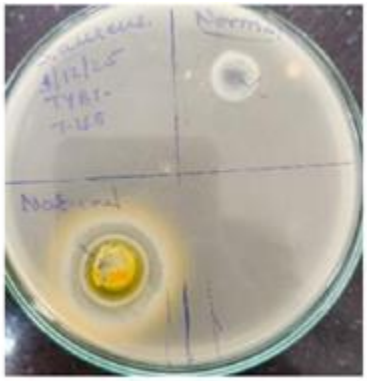
marigold powder along with 5ml of aloe vera gel and 1 capsule of Vitamin E, stirring continuously to ensure the herbal ingredients were evenly distributed.

This method aligns with standard protocols for creating natural alternatives to synthetic soaps that often cause skin irritation (Ghonge et al., 2025). The use of a glycerin base further ensures the soap remains gentle and helps the skin retain moisture (Mahesh et al., 2025). The homogenized mixture was then poured into molds and kept in a cool place to harden and desiccate (Yardani et al., 2023).

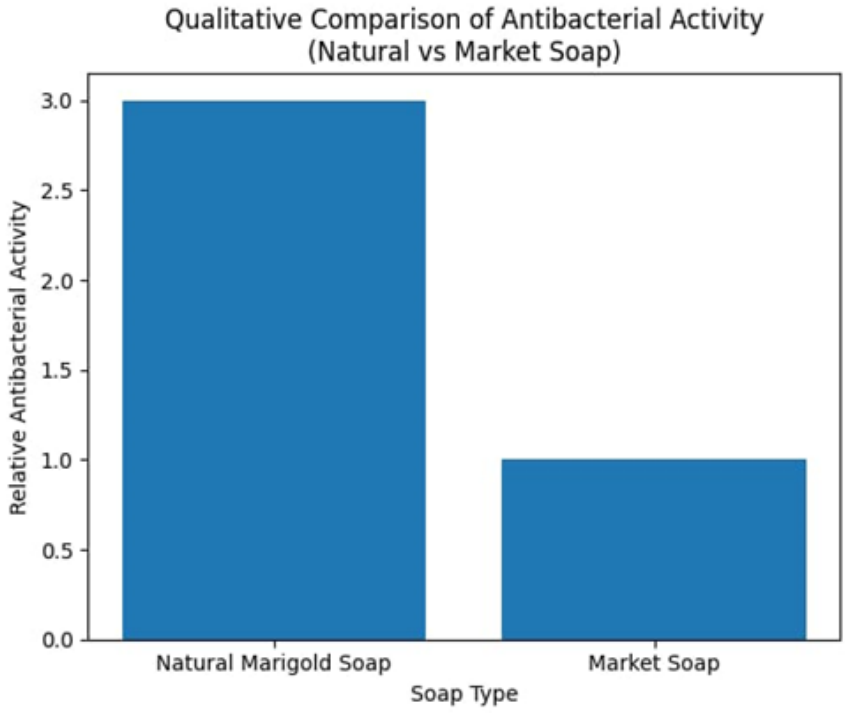
a. Collection of flower waste

b. Addition of soap base

c. After boiling water bath liquified soap



d. Solidified Soap



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Determining its effect against *S.aureus* and comparing it with marketed soap

METHODOLOGY FOR DHOOP PREPARATION

Collection and Preparation of Raw Materials:
Discarded marigold (*Tagetes spp.)* flowers were collected and air-dried to remove moisture. The dried flowers were then finely powdered using a mortar and pestle (Jadhav et al., 2025). Cow dung was collected and sun-dried, followed by grinding to obtain a uniform powder (Jadhav et al., 2025).

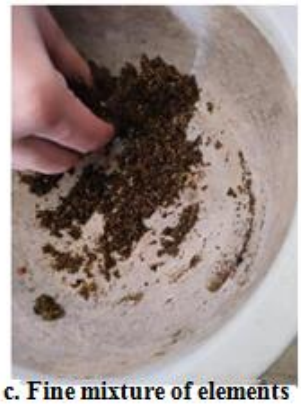
Formulation of Dhoop Mixture:
The powdered marigold flowers were mixed with powdered cow dung, which acted as a natural binder and combustible base (Jadhav et al., 2025). Small quantities of camphor (kapoor) were added to enhance fragrance and ignition properties, while clarified butter (ghee) was incorporated to improve burning stability and flame consistency. The dry ingredients were mixed thoroughly to ensure homogeneity.

Molding and Drying of Dhoop:
Water was added gradually to the mixture to obtain a pliable dough-like consistency. The mixture was then hand-molded into cone-shaped dhoop sticks (Jadhav et al., 2025). The molded dhoop cones were air-dried at room temperature until complete hardening was achieved.

Evaluation of Dhoop Quality:
The prepared dhoop cones were evaluated qualitatively based on ease of ignition, uniformity of burning, fragrance release, and smoke characteristics during combustion (Jadhav et al., 2025)


a.Flower waste


b.Cow dung


c. Fine mixture of elements


d. Incense sticks


e. Testing out

4. RESULT

4.1 Evaluation of Handmade Paper
The produced paper demonstrated uniform texture and mechanical strength, confirming that floral waste is a viable sustainable alternative to wood pulp (Jadhav et al., 2025). The sheets retained a natural aesthetic without synthetic dyes.

4.2 Performance of Polyherbal Soap
The soap showed a skin-neutral pH and high foaming capacity. In line with Mahesh et al. (2025), the herbal extracts provided antioxidant benefits, while antibacterial tests against S. aureus showed a larger zone of inhibition than commercial brands, proving superior protection (Yardani et al., 2023)

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4.3 Impact of Bio fertilizer on Plant Growth

Bio fertilizer trials on Vigna radiata showed that ash-treated plants had higher germination rates and shoot development compared to the control group. This validates floral ash as an effective nutrient source for sustainable agriculture (Reddy et al., 2025).

4.4 Combustion Quality of Natural Dhoop

The dhoop cones ignited easily and released a mild fragrance with low smoke density. This successfully repurposes biodegradable waste into an eco-friendly aromatic product that meets consumer safety standards (Jadhav et al., 2025).

5. CONCLUSION

The study demonstrates that marigold flowers can be effectively utilized in multiple eco-friendly applications. Marigold flower ash supported plant growth, indicating its potential as a natural nutrient source. The marigold-based dhoop showed sustained burning and natural fragrance, suggesting suitability as a herbal alternative to synthetic incense. The natural marigold soap exhibited superior antibacterial activity compared to commercial soap in the agar well diffusion method. Overall, marigold flowers show strong potential for developing sustainable, biodegradable, and multifunctional natural products

6. FUTURE PROSPECTS

The findings of this study open several avenues for future research and practical application. Large-scale trials can be conducted to evaluate the commercial feasibility and cost-effectiveness of producing handmade paper, biofertilizer, soap, and dhoop from floral waste. Further optimization of processing parameters may improve product quality, durability, and shelf life, particularly for personal care and incense products.

Advanced chemical and microbiological analyses are recommended to assess long-term safety, nutrient release behavior, and antimicrobial efficiency, especially for biofertilizer and soap formulations. Field-based agricultural studies can be undertaken to quantify crop yield improvement and soil health enhancement using marigold-derived ash.

Future work may also explore the utilization of mixed floral waste and other flower species to expand product diversity. Integration of this valorization model with organized floral waste collection systems from temples, markets, and festivals can enhance scalability and contribute to sustainable waste management, green entrepreneurship, and circular bioeconomy development.

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