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Review on floral waste utilization: A sustainable and ecofriendly approach

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Abstract

In India, an estimated 108,000 temples and mosques generate a substantial amount of floral waste daily, with approximately 8 million tons annually ending up in landfills or polluting water bodies. This often-overlooked issue, exacerbated by numerous festivals throughout the year, leads to foul odors and significant environmental harm due to the highly biodegradable nature of flowers. Cities with high concentrations of temples experience a tenfold increase in such waste. However, this floral waste, rich in nutrients and lignocellulosic materials, presents a valuable resource. It can be repurposed for Compost making, Biofuel and biogas generation, Extraction of dyes and essential oils, reduction of eco-friendly products like Holi colors, incense sticks, soaps, and handmade paper, Art and craft applications by transforming this waste, India can mitigate pollution and promote a more sustainable environment. In this paper, we have reviewed the ways by which flower waste can be utilized, managed to get valuable products and thus conserving the environment are explained.

Keywords: Flower, floral waste, vermicomposting, bio fuel, natural dye

Introduction

India is one of the foremost religious nation from all religious places, an outsized quantity of flower waste is generated and it's improperly dumped in open places or any water body like pond, lake, and river. Out of this solid waste about 40-50% organic in nature and contributing to the environmental pollution (air, soil, and water) and human health also affected by this solid waste. In India, nearly 4.74×10^6 t/day floral waste is released from different religious and social programmes after a single- use. Every day, worshippers bring a large number of flowers to religious sites, which are then left unused and thrown away. This large amount of floral waste is collected at religious sites like as temples, gurudwaras, and mosques, as well as from residential neighbourhoods, community centres, and other locales. After Andhra Pradesh (AP), Karnataka, and Tamil Nadu, West Bengal ranks fourth in India in terms of flower promotion. Banaras (UP), one of India's holiest cities, lacks enough coverage for the disposal of large amounts of flower debris. Every day, 3.5-4.0 tonnes of flower waste is deposited behind the temples. This big quantity of floral waste may be controlled with the aid of using changing it into consumable items like herbal colors for silk and cotton products, perfumes, incense sticks, indoors ornamental items, composts, biogas, etc. Many investigators have developed eco-friendly bio-sorbents to get rid of heavy metals and toxic dyes by using flower petals from water sources. (Perumal *et al.*, 2012) ^[9]

Floral Wastes Disposal and Problems Associated Due to Their Improper Disposal

Country like Srilanka and India, where about 40% of the total production of flowers are unsold and wasted daily. These flowers are thrown into water or dumped into landside causing water pollution as well as environmental pollution. Many of us avoid throwing flowers and other items which are used for prayers in the garbage and instead put them in the plastic bags and throw them directly in the water bodies. Such disposal of waste creates problems like eel and worm development, water and land pollution and foul odor. Solid waste and littering can degrade the physical appearance of water bodies and cause deterioration of water quality. The floral waste generated gives a filthy look to the streets and roads and also distorts the image of ghats along the rivers. (Waghmode *et al.*, 2016) ^[18]

Management

Vermicomposting

Floral waste as a soil conditioner in the form of vermicompost floral waste being one of the biodegradable portions of the municipal solid waste can be converted into soil conditioner in the form of vermicompost. Compost made from flower waste is high in key nutrients like nitrogen, phosphorous, calcium, and potassium, as well as micronutrients like iron, magnesium, and copper, making it a valuable agricultural commodity. After collection of flower waste from its sources, they are sorted and shredded into small pieces. Segregated floral waste are air-dried and subjected to pre-composting and further composting is done using earthworm species such as *Eisenia foetida*. (Jain, 2016)^[3].

Makhanial and Upadhyay (2015)^[20] investigated the heap composting method for floral waste, monitoring key physicochemical parameters. They observed that temperatures peaked around the 4th day before gradually declining. PH initially decreased, then increased. Electrical conductivity showed minor fluctuations, while moisture content rose for about a week before decreasing. The study concluded that covering the heap with a polythene sheet promoted fungal growth and increased temperature, ultimately proving composting to be an effective "zero-waste" approach for managing organic materials like flower. Ravinder Kohli and Hussain (2016)^[11] conducted a vermicomposting experiment using *Eudrilus eugeniae* earthworms in portable HDPE beds, maintaining a 60% moisture content. After 45 days, they observed several changes: the pH shifted from alkaline to neutral, electrical conductivity initially increased by day 15 but then decreased by days 35 and 45, and the carbon-to-nitrogen (C/N) ratio decreased, indicating efficient mineralization of the waste material.

Tiwari and Juneja (2016)^[15] conducted in earthen pots (9 pots) with size of 26.5×35 cms. Pots were first washed and dipped in water overnight. In each pot a measured amount of the substrate (floral waste), mixed with cow dung was taken in different proportions depending on the ratios viz., 50:50, 60:40, 70:30, 80:20 and 90:10 for vermicomposting and composting. Cow dung was used as an inoculant in the vermicomposting process; it enhances the quality of feeding resource attracting the earthworms and accelerates the breakdown of wastes. It was left for a day to remove excess heat. In the present study *Eisenia foetida*, commonly known as red worm was used. By this they concluded that the total weight of the vermicompost obtained from vermicomposting of floral waste were 755.0 g (50:50), 775.5 g (60:40), 685.5 g (70:30), 654.0 g (80:20) and 620.0 g (90:10). The percent conversion of vermicompost was 62.9% (50:50), 64.4% (60:40), 57.1% (70:30), 54.5% (80:20) and 51.6% (90:10). The highest rate of bioconversion was shown by 60:40. the floral waste with cow dung at 50:50, 60:40 and 70:30 could be bio converted into a nutrient rich vermicompost. The remaining two ratios i.e. 80:20 and 90:10 can be ruled out because the values of two major macronutrients; phosphorus and potassium were lesser as compared to other ratios. Vermicomposting is a suitable technology for bio conversion of flowers into value added compost and reduction of solid waste pollution, Floral waste: cow dung @ 60:40 promising high value bio-fertilizer. Help to reduce volume of temple waste and to generate additional revenue for the temples.

Paturkar *et al.* (2022)^[8] conducted the experiment on the comparative study of vermi-cast generated from flower waste and leaf waste and flower waste from nearby holy places were collected. Layers of dry cow dung mixed with soil and decayed leaf waste and flower waste are made in respective tanks. Culture of earthworm *Eisenia foetida* of same quantity was inserted and keep it for biological decomposition to produce organic fertilizer. from this They concluded that that percent of C:N ration and Organic C is high in vermicast generate from floral waste than leaf waste. The concentration of nitrogen (134.6mg/L) was found to be highest in earthworm cast generated from flower waste than in cast generated from leaf waste (86.16mg/L). The concentration of potassium was found to be more in leaf waste (108.30 mg/L) than the flower waste (94.33 mg/L) The concentration of Zinc (9.415 mg/L) was found to be highest in leaf waste while concentration of Zinc in flower is (2.805 mg/L). The concentration of remaining elements Sulphur, copper, iron, boron and carbon nitrogen ratio was found to be nearly same or no significant change. Casts generated from flowers and leaves separately will be beneficial in overcoming deficiencies of particular essential element in plants.

Sharma and Yadav (2017)^[2] utilized Response Surface Methodology (RSM) to optimize flower waste vermicomposting. Their research, employing *Eisenia foetida* with cow dung, demonstrated that the resulting compost was rich in beneficial nutrients like sodium, potassium, and phosphorus. This process effectively converts flower waste into valuable organic manure, thereby reducing waste volume.

Bio gas and bio fuel production

Singh and Bajpai (2012)^[13] conducted an experiment in Lucknow, India, under cold atmospheric conditions, focusing on the anaerobic digestion of flower waste to produce methane. Using a gas chromatograph to analyze the gas quality, they concluded that this process effectively mitigates the pollution caused by flower disposal. Furthermore, it demonstrated the ability to remove pollutants such as Biochemical Oxygen Demand (BOD) and Total Solids (TS), while simultaneously generating valuable biogas.

Kumar and Swapnavahini (2012)^[5] investigated the anaerobic digestion of rose residue in a 2.5 L batch reactor over 30 days at room temperature to produce biogas and reduce nutrient content. Their analysis, conducted at 5-day intervals, showed significant reductions in various parameters: Total Solids (TS) by up to 73%, Volatile Solids (VS) by 45%, Chlorides by 82%, Biochemical Oxygen Demand (BOD) by 42%, and Total Kjeldahl Nitrogen (TKN) by 58%. Biogas was produced, though its generation was hindered due to "pickling" of the reactor, likely referring to an acidic imbalance that can inhibit the anaerobic digestion process.

Ranjitha *et al.* (2014)^[10] conducted a lab experiment using a 1-liter anaerobic digester with cow dung as an inoculum to produce biogas from vegetable and flower waste. Their findings indicated that flowers yielded significantly more biogas (16.69 g/kg) compared to vegetable waste (9.089 g/kg), and the digestion process for flowers was also faster. They concluded that flowers, being readily available in India, are an excellent feedstock for biogas production, offering a sustainable way to transform waste into a valuable resource.

Kulkarni and Ghanegaonkar (2019) ^[4] Experimented for biogas generation are conducted to understand biogas

generation cannot take place from untreated flowers. And the flowing treatment taken as mentioned in the table 1

Table 1: Pretreatments, Feedstock and Chemicals used for conducting pilot experiment

Sl. no	Pretreatments used	Feedstock and chemicals	Findings
1	No pretreatments	A mixture of fresh flowers	No biogas generation from fresh and untreated flowers
2	Chemical pretreatment only using NaOH	A mixture of flowers + NaOH	Less biogas output
3	Drying and NaOH chemical pretreatment	Rose, aster and marigold flowers	Aster and marigold flowers have good biogas potential
4	Drying and chemical pretreatments	Marigold and aster flowers + NaOH	For 100g flowers - 8g NaOH (marigold) and 4g NaOH (aster)

The digester temperature, pH of the slurry, retention time, feeding frequency and the use of catalysts for biogas generation has a major impact on volume and quality of biogas produced. Various pretreatments like mechanical pretreatment, chemical pretreatment, thermal pretreatment or biological pretreatment applied to the feedstock are effective for enhancement of biogas production from the digester. Pretreatment of the feedstock increases its biodegradability by opening its structure, making it more accessible for the enzymatic attack. Experimental investigation of alkaline pre-treatment floral waste using sodium hydroxide increases methane production and fresh flowers without any pretreatment cannot produce biogas

Natural dye, pigment extraction

Vankar *et al.* (2009) ^[16] determined that flower waste, specifically marigold petals rich in carotenoids (lutein) and flavonoids (patuletin), can be industrially used to create dyes for textiles like cotton, wool, and silk. They successfully identified, isolated, and applied these colorants, achieving good dyeing results, especially when textiles were pretreated with 1-2% metal mordant and 5% plant extract.

Teli *et al.* (2013) ^[14] successfully extracted natural dyes from hibiscus and marigold flowers. These dyes were then used to color cotton and cotton/silk blend fabrics, with the assistance of natural mordants such as alum and ferrous sulfate. Their research concluded that the extracted dyes exhibit strong potential for effectively dyeing these fabric types.

Ravishankar *et al.* (2014) ^[12] highlighted the significant amount of flower waste (approximately 1450 tonnes) generated from religious offerings in India, including varieties like rose, jasmine, and marigold. They investigated methods to extract valuable products from these discarded flowers. For dye extraction, dried and ground flowers were dissolved in solvents such as ethanol, methanol, and hexane. Essential oils, on the other hand, were extracted using a Soxhlet apparatus, where a mixture of fresh flowers and a suitable solvent was heated to obtain the desired distillate. Their findings confirmed that the extracted dyes were satisfactory for use on clothing.

Singh *et al.* (2017) ^[19] investigated natural dyes extracted from biodegradable temple and household waste materials. They used ultrasonication to extract the colors, followed by spray drying. These natural dyes were successfully applied to various fabrics including cotton, silk, and wool. Importantly, the study also noted that the residue remaining after dye extraction was nutrient-rich, suggesting its potential for further use as a valuable resource itself.

Nair *et al.* (2022) ^[7] conducted the experiment to extract natural dye from waste flowers of *Aster chinensis* and

further test its application as pH indicator in acid-base titrations. Two varieties of Aster flowers with light pink and dark pink petals were obtained from local markets of Mumbai. These flowers were stored and used after 3 days. The waste aster petals were then plucked. Sample preparation was done by separating these petals on the basis of their colour onto two different trays at room temperature. These petals were then subjected to Soxhlet extraction. The property of aster flower extracts as pH indicators was screened based on their efficiency in detecting neutralization reactions. End points obtained for various combinations of titrants and titrands by using aster petal extracts as indicators were compared to those obtained after using phenolphthalein and methyl red pH indicators extracts of both dark pink and light pink hued petals yielded similar end point readings. Furthermore, these waste flower petal extracts displayed end point values that were in concordance with the end points obtained from titrations with phenolphthalein and methyl red indicators. This highlights the usefulness of these waste aster petal extracts as a suitable pH indicator.

Handcrafted products from flower waste

Handmade paper

Producing hand paper from flower waste not only contributes to effective floral waste management but also plays a crucial role in reducing deforestation. 100% wood free, Bring down deforestation, Free of all chemicals, Eco-friendly, cost-effective and biodegradable.

Many communities transform flower waste into valuable products like incense sticks, using various flowers such as marigolds, roses, jasmine, and hibiscus as raw materials. These flowers are first sorted, dried, and then pulverized. Even rotten petals find a use, being converted into herbal homemade soap with ingredients like sodium hydroxide (lye).

Nowadays many organizations are coming up with innovative technologies for incense stick production. With CSIR-CIMAP interventions under a project named "MISSION SAKSHMA" a huge amount of floral waste are being segregated and used to make fragrant incense sticks, were Tulsi leaves used to scent incense stick by 'CSIR-Aroma mission'. Technology like, the dried flowers were mixed with binding agents (gum Arabic and Makko powder), along with a small amount of charcoal to make them combustible.

Beyond these, flower waste can be repurposed into a wide array of useful items, including pigments, colors, foodstuffs, sugar syrup, biofuels, compost, biogas, organic acids, and bioethanol. A notable example of this sustainable practice is seen in Shirdi, Maharashtra, where approximately 2 metric

tons of flower waste are processed daily to produce 80 kg of agarbatti (incense sticks), which are then used within the Shirdi Sansthan premises for prayers to Shirdi Saibaba (CPHEEO 2018)^[1].

Waghmode *et al.* (2018)^[17] found that temple floral waste can be repurposed into handmade paper, offering an eco-friendly solution to reduce discarded waste from urban temples and promote recycling.

Conclusion

Temple floral waste, though often overlooked in favor of industrial pollution, poses significant environmental and health threats. However, existing research demonstrates that this waste can be transformed into a range of valuable products, including pigments, incense sticks, food items, compost, biofuels, biogas, bioethanol, and handmade paper. By promoting awareness and actively utilizing floral waste, we can reduce its societal burden, leading to a cleaner and healthier environment. Implementing a "green temple concept" could also provide a framework for government policies on waste management and foster sustainable development within religious institutions.

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