Management of Floral Waste by Conversion to Value-Added Products and Their Other Applications

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REVIEW

Management of Floral Waste by Conversion to Value-Added Products and Their Other Applications

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Abstract Solid waste disposal is major problem in the world. Agricultural residues, temple waste, domestic waste, non-edible oil cakes waste are enriched with carbon content. Landfilling remediation approach is used for disposal of organic waste. Floral waste is one of the major concern. Flowers have applications in many industries viz; perfumes, cosmetics, food, liquor and textile industries. Disposal of flowers in rivers, oceans, etc. leads to water pollution as well as affects the living organisms present in the waters. This review describes the management of floral wastes by solid state fermentation for the conversion into different value-added products viz; compost; biofuels; biogas; bioethanol; organic acids; pigments; dyes; polyhydroxybutyrate-*co*-hydroxyvalerate production; food products; biosurfactants production; sugar syrup; incense sticks; etc. The floral waste is also a source for handmade paper production. These value-added products will have different applications; viz; compost can be used for various plant growth; biogas for electricity generation; food products as nutrients and additives. The dyes and pigments from floral wastes will have applications in various textile industries; while biofuels and bioethanol can solve the problem of energy crisis. The waste can thus be converted into wealth. The review highlights the industrial applications of value-added products obtained from the floral wastes. The review also focuses on important application of floral wastes in biosorption which will help in the treatment of waste waters and other industrial effluents. This will resolve the problems of disposal of floral waste and ultimately the water and environmental pollution will also be reduced.

Keywords Value-added products · Floral waste · Solid state fermentation · Polyhydroxybutyrate-*co*-hydroxyvalerate · Biofuels

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Introduction

Waste disposal is a major concern in the world. Diversity in the content of waste create problem in its reduction. Safe disposal of floral waste has been a cause of concern for the temple management. The floral waste is directly disposed into the rivers, oceans, etc. which has bad impact on the water quality as well the living organisms present in the waters. Flowers come as waste from hotels, wedding ceremony gardens, worship places and various civilizing and sacred ceremonies, which make them a usual source of floral waste. Flowers are considered as holy entities and hence are offered by pilgrims to their idols. Every day these flowers offered by the devotees in temples are left unused and therefore become waste. This flower waste gets accumulated at religious sites like Temples, Mosques and *Gurudwaras* due to a number of religious practices and is also generated in places like residential areas, community centers, etc. In India, West Bengal is in 4th position to promote flowers after Andhra Pradesh, Karnataka and Tamilnadu. Banaras, one of the holiest cities of the country, has no policy for the disposal of the tones of waste.Every day waste material weighing 3.5–4.0 ton is left behind in the city of temples [1]. Another example is of floral waste generation in the temples of Chitrakot. Every day many devotees offer flowers in the temples of Chitrakoot. There are two main places where flowers are sold. One is situated in the Ramghat on the bank of river Mandakini and another on the platform of Lord Kamtanathji. Total floral waste in Ramghat and plateform of Lord Kamtanathji generated is 5.48 ton year^{-1}. Other place where the floral waste generated is Prasadam, which was found to be 2.08 ton year^{-1}. The Varanasi Nagar Nigam estimates the quantity of floral waste to be 10 ton day^{-1} in the city. The status of offered flowers in selected temples of Chennai is shown in Table 1. Degradation of floral waste is a extremely slow process as compared to degradation of kitchen waste [2]. Hence proper and eco-friendly process for floral waste treatment are required. Studies reveal the management and utilization of flower waste can been carried out. The waste of flower in Durga temple, Durgakund Varanasi includes *Hibiscus rosa sinensis* (Gudhal); in case of Vishwanath temple marigold (Genda) flower with rose and in shiv temple Mrityujaya mahadev, Visheshwarganj, Varanasi the flower waste includes *Calotropis gigantea* (Madar). The Dutch produces 4.32 billion tulip flowers each year, 2.3 billion are grown into cut flowers. Of these, 1.3 billion (57%) are sold in the Netherlands as cut flowers 630 million bulbs and 370 million are exported in Europe and outside of Europe). The percentage of flowers sold and unsold and remaining disposed to waterbodies and as garbage is represented in Fig. 1. Some flower merchants dump flower wastes in the street which might lead to outbreak of serve endemic diseases as the garbage attracts pests [3]. During rainy season, the condition becomes worse with mosquitoes and flies breeding on the waste. Also there is a serious issue of the leachate production from the flower waste, which ultimately if mixed with river water or well water will cause health issues. There are very few reports on management of floral waste. The mini-review here highlights the issues of floral wastes and how the management of floral waste can be done by converting them into wealth, i.e., many value-added products. The floral wastes can also have important application in biosorption which will help in the treatment of waste waters and other industrial effluents. This will resolve the problems of disposal of floral waste and ultimately the water and environmental pollution will also be reduced. Also, there are very few reports on the management of floral wastes by conversion to value-added products.

Floral Wastes Disposal and Problems Associated Due to Their Improper Disposal

There are some standard disposal and treatment options, landfilling; incineration which is controlled combustion of waste materials to a non-combustible residue or ash and exhaust gases. In USA and Europe, incineration is preferred for many organic hazardous and toxic waste streams. In land treatment final state of the waste is disposed by making intimate contact with the soil. The land treatment exploits the natural capacity of the soil to return substances to a condition forthcoming the unique state from which they were won by a process of extraction and purification. Volatilization method is also used for the treatment and disposal of wastes. It is effective for the removal of volatile compounds from soil by using commercial units that heat up the soil to between 100 and 500 A °C. Dried and decayed flowers are considered waste material and thus, dumped in landfills, various waterbodies, etc. The example is of a country like Srilanka and India, where about 40% of the total production of flowers are unsold and wasted daily [4]. These flowers are thrown into water or dumped into landside causing water pollution as well as environmental pollution [5]. 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. However, now there is a modern approach to convert the floral wastes into value-added products viz., compost; biofuels; bioethanol; organic acids; pigments;

Table 1 Status of offered flowers in selected temples of Chennai. *Source*: [53]

Temple	Flowers	Quantity of flowers (kg day^{-1})	Quantity of wasted flowers (kg day^{-1})
Ashtalakshmi, Besantnagar	Jasmine, marigold, rose	1000	200
Marudeeshwar, Thiruvanmiyur	Jasmine, rose, chrysanthemum	950	125
Kabaleeshwar, Mylapore	Rose, marigold, chrysanthemum	2500	800
Murugan, Vadapalani	Jasmine, marigold, rose	1500	400
Sri Parthasarathy, Light House	Rose, marigold, chrysanthemum	1200	400

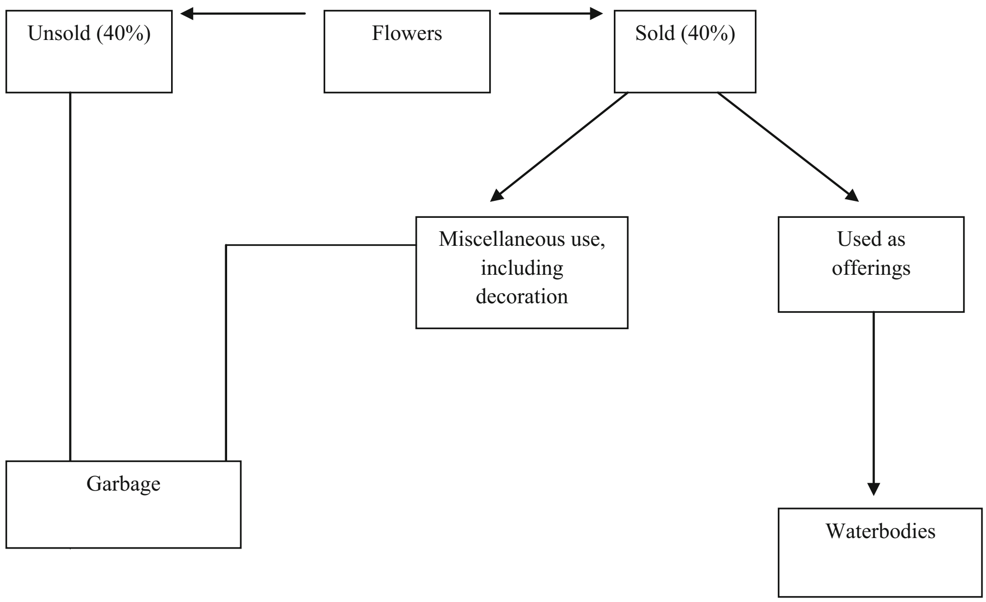

Fig. 1 Percentage of flowers sold and unsold and remaining disposed to waterbodies and as garbage [52]

dyes; polyhydroxybutyrate-*co*-hydroxyvalerate production; food products; biosurfactants production; sugar syrup; incense sticks; handmade paper production; etc.

Flowers, Their Production and Composition

Mahua is a deciduous tree found in tropical rain forests of Asian and Australian continents [6]. The flowers and seeds of mahua tree are very useful in Indian sub-continent and re employed to produce biofuels such as ethanol and biodiesel from flowers. The annual production of mahua flowers in India during 2001 was about 45,000 Megaton [7], which has remained constant during 2005 [8]. The edible part of the mahua plant is its flower. Various fermentable sugars (glucose, fructose and maltose) in ethanol extract of mahua flowers by thin layer chromatography (TLC) have been analyzed [8].

Safflower (*Carthamus tincttiorius* L.) is world's oldest crops which is highly branched, herbaceous, thistle like annual herb. The color of flower varies from whitish yellow to red orange. India is the largest producer of safflower (2 lakh ton) in world with highest acreage (4.3 lakh hectare). The valuable safflower petals are being wasted and its therapeutic value is also ignored. Safflower composition (mg/100 g): potassium: 3992; calcium: 558; magnesium: 207; iron: 55; sodium: 1043; manganese: 4.34; zinc: 2.88; total sugar: 7.36% and protein: 12.86%.

African Marigold flowers are seen in different colors, i.e., orange, yellow, gold and bronze.

Rose flowers vary in size and shape and are usually large and showy, in colors ranging from white through yellows and reds. Most species are native to Asia, with smaller numbers native to Europe, North America, and northwest Africa. Species, cultivars and hybrids are all widely grown for their beauty and often are fragrant.

The flowers have characteristics patterns on their petals. The patterns are more distinctive such as pansy's stripes, the fritillary's checks or the tiger-lily's dots, or more subtle in the form of characteristic veins in the petals.The FTIR and scanning electron microscope images of dried and crushed marigold flower is represented in Fig. 2 and Fig. 3a–c respectively.

The FTIR peak value of dried and crushed marigold flower is represented in Table 2. The FTIR spectroscopic analyses revealed the presence of different functional groups present in dried and crushed marigold flower in the form of peaks. The results of FTIR spectrum showed a frequency range 3986.5 cm^{-1} representing the OH stretching and indicated the presence of alcohol and phenol. The peak obtained at 2953.6 cm^{-1} indicated the C–H stretching and indicated the presence of alkanes. The peak obtained at 1416.1 and 604.80 cm^{-1} indicated the –C=C– stretching and –C (triple bond) CH: C–H bend and mainly the presence of alkynes. The peak obtained at 1723.6 cm^{-1} indicated the N–H bending and showed the presence of primary alkanes. The peak obtained at 1416.1 cm^{-1} indicated the C–C stretching and showed the presence of aromatic compound. The peak obtained at 1034.5 cm^{-1} indicated the C–N stretching and confirmed the presence of aliphatic amines. The peak obtained at 827.1 cm^{-1} indicated the N–H bending and confirmed the presence of amines.

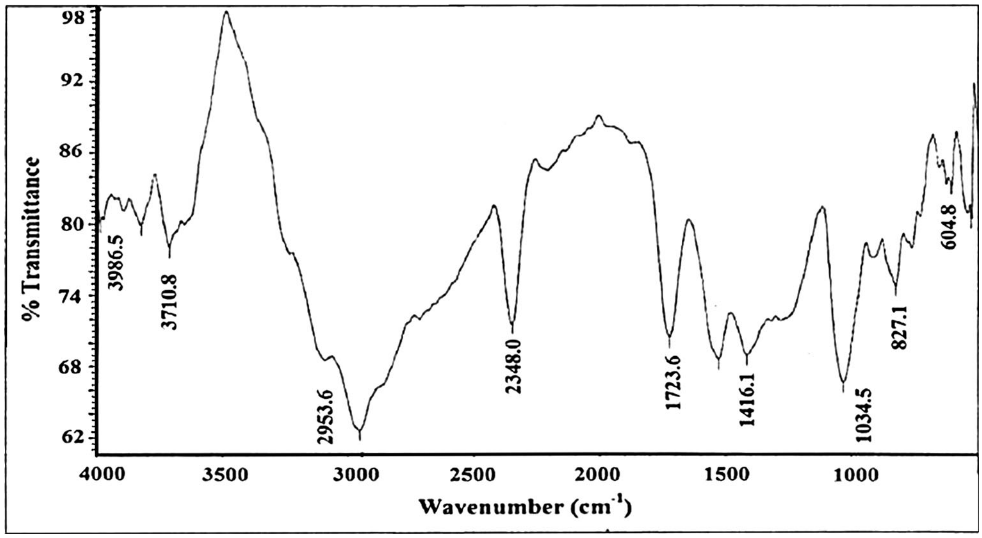

Fig. 2 FTIR image of the dried and crushed marigold flower

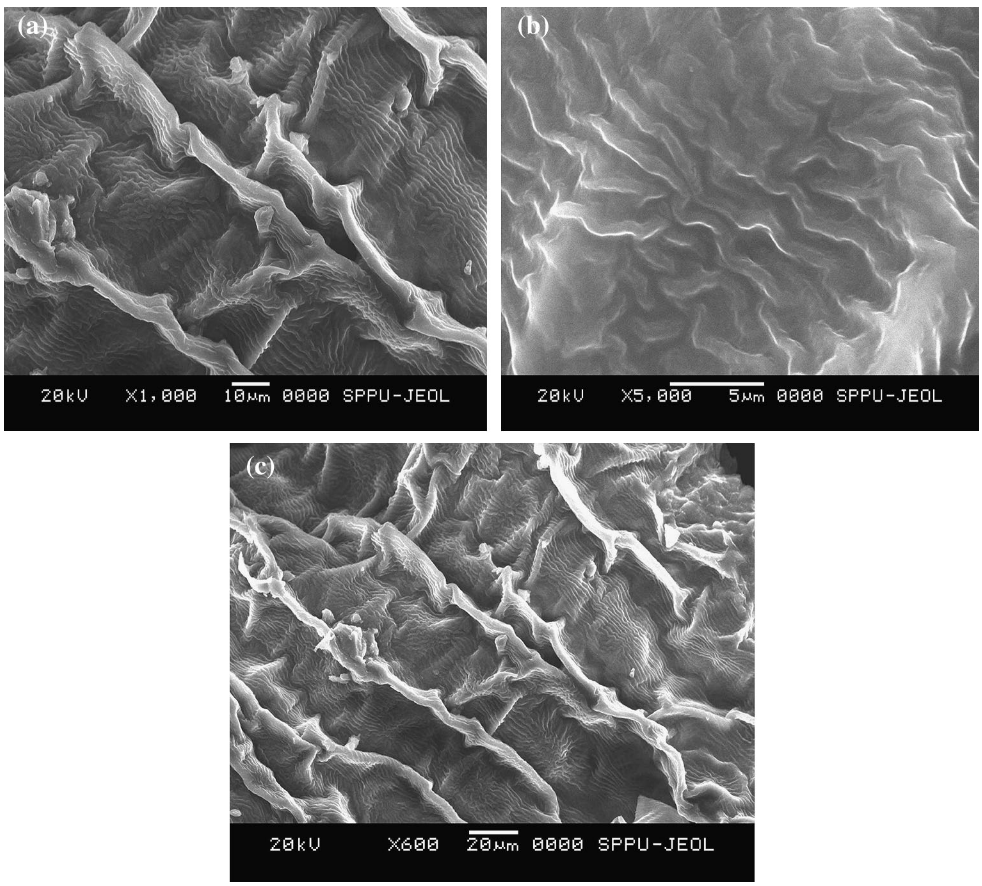

Fig. 3 **a, b** and **c** Scanning electron microscope image of dried and crushed marigold flower

Fermentation

There are reports on bioethanol production using solid state fermentation technique. There is a report on ethanol fermentation of mahua flowers (*Madhuca latifolia* L.) flowers using free and immobilized yeast *Saccharomyces cerevisae* [8] and 8.94% ethanol yield from mahua (*Madhuca indica* J.F. Gmel) flowers using soil bacteria [9]. Also there is a report on ethanol fermentation of mahua flowers using free and immobilized bacteria *Zymomonas mobilis* MTCC 92.

Table 2 FTIR peak value of dried and crushed marigold flower

Peak value frequency (cm^{-1})	Bond	Functional group
3986.5	O–H stretch	Alcohols/phenols
3710.8	O–H stretch	Alcohols/phenols
2953.6	C–H stretch	Alkanes
2348.0	–	Unknown
1723.6	N–H bend	Primary alkanes
1416.1	C–C stretch	Aromatics
1034.5	C–N stretch	Aliphatic amines
827.1	NH bending	Amines
604.8	–C(triple bond) C–H:C–H bend	Alkynes

Solid State Fermentation (SSF)

SSF is the fermentation process occurring in the absence or near-absence of free water. SSF processes employ a natural raw material as carbon and energy source. Solid substrates generally provide a good dwelling environment to the microbial flora comprising bacteria, yeast and fungi [9]. SSF has been used for the production of value-added compounds viz., enzymes, organic acids, biopesticides, biofuel and flavours. In the last years, new applications of SSF in the environmental control have been developed including bioremediation and biodegradation of hazardous compounds and the detoxification of agroindustrial residues. SSF for the production of ethanol from mahua flowers has been studied. The highest ethanol productivity (3.13 g kg^{-1} flower h^{-1}), yeast biomass (18.5 × 10^8 cfu g^{-1} flower), the ethanol yield (58.44 g 100 g^{-1} sugar consumed) and the fermentation efficiency (77.1%) were obtained [10]. There is a report on *Eucalyptus citriodora* flowers as fermentable substrate [11].

Types of Fermentation and Advantages of Flower as Fermentable Substrate

There are various types of fermentation viz., ethanol, lactic acid, propionate, mixed acid and butanediol, butyrate and acetone–butanol and homolactate fermentation. Various substrates are used which are agroindustry by-products; sugars; organic acids; polyols; etc. Flower wastes have many distinct advantages for use as fermentable substrate, viz., high content of sugars; available freely everywhere on earth and economical [12].

Value-added Products from Floral Wastes

The solid state fermentation can help convert floral waste into many value-added products viz., compost; biofuels; bioethanol; organic acids; pigments; dyes; polyhydroxybutyrate-*co*-hydroxyvalerate production; food products; biosurfactants production; sugar syrup; incense sticks; etc. The floral waste is also a source for handmade paper production.

Compost/Soil Conditioner

Flowers can be used as substrate for vermicomposting. Vermicomposting is a suitable technology for bioconversion of flowers into value-added compost and reduction of solid waste pollution. It can be successfully applied in temples as a solid waste management strategy with flowers as the major organic waste. This can be important alternative approach in sustainable waste management. Vermicomposting technology for bioconversion of flowers into value-added compost will help reduce volume of temple waste and also generate additional revenue for the temples. The organic fractions of flower waste vermicompost and microorganisms in the biofertilizers can be an alternative to chemical fertilizers to improve the growth and yield of various plants. There is a report of solid waste management of temple floral offerings by vermicomposting using *Eisenia fetida* [13]. The main advantage of vermicomposting is that it is one of the eco-friendly technology since it overcomes the problem of organic waste disposal and also alleviates the odor problem. Vermicomposting also cleans the environment and provides remunerative organic manure. Mahua floral waste can be converted into a compost or soil conditioner, a value-added product. The compost or soil conditioner from mahua floral waste can be used to increase the growth of many plants. Kashi Vishwanath temple which draws maximum devotees all round the year, especially in the month of *Shrawan*, has its own system for the disposal of the hundreds of kg of waste resulting from offerings by devotees. Another case in point is the Vishwanath temple, where floral waste is converted into manure [1]. The conversion of floral wastes into vermicompost using floral wastes (rose, jaswand and mogra) [14]. The vermicompost obtained was rich in carbon

(28%), nitrogen (1.58%), phosphorus (0.33%) and potassium (0.28%). The vermicomposting has been carried to convert floral waste into useful organic fertilizer [15, 16]. The temple near SIES Nerul, Thane have undertaken project where the floral waste (flowers; garlands and offerings) which otherwise were thrown in the municipal bin are now converted into nutrient rich manure. The nutrient rich manure formed can be used as additive for providing the nutrients for the growth of the plants which is very essential. In Kenya, the floral waste generated is converted to compost and soil conditioner. The vermicompost production from floral wastes is shown in Fig. 4.

Biofuels, Bioethanol and Biogas Production

Microorganisms are used as a tool by fermentation biotechnologists for the conversion of sugar into ethyl alcohol. Due to severe energy crisis in today's world, ethanol is considered most suitable energy source amongst different fossil fuels. In India, various parts of Andhra Pradesh, Maharashtra, Chhattisgarh, some tribal communities are involved in cultivating and harvesting mahua flowers for alcoholic beverages using traditional methods. Mahua flowers are used for the production of vinegar and alcohol production. Preparation of sugars and analysis of flowers from various districts have been studied. The utilization of mahua flower as a substrate for the production of ethanol through submerged fermentation is of great economic advantage [17]. Flowers which are available in abundance in India including the immediate environment is a very good feedstock for biogas production [18]. Flowers give high yields of biogas and at faster rate which is important advantage. Study has been done on biogas production using floral wastes as raw material [19]. There is a report on biogas production from rose by anaerobic digestion in a batch reactor [20]. The biogas from floral waste can be used for electricity generation and as a fuel. The amount of biogas kg^{-1} substrate from flower wastes in Kenya is shown in Table 3, where the amount of biogas kg^{-1} substrate is more from silk tree Mimosa. The flow diagram representing flower as fermentable substrate in fermentation for biofuels and biodiesel production is shown in Fig. 5.

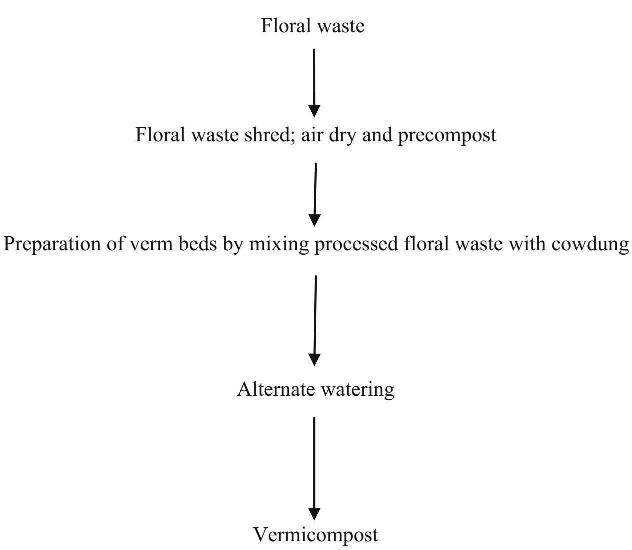

Fig. 4 Flowsheet showing vermicompost from the floral wastes

Organic Acids, Dyes and Pigments

In India, major raw material for oxalic acid is sugarcane. In view of the occurrence of more sugar in mahua flowers, it constitutes an alternate potential to oxalic acid production [21]. Oxalic acid is largely used as a preservative and chelating agent. There is a report where marigold and rose flowers from temples of Aurangabad have been used for the preparation of dyes [22]. Biodegradable dyes have emerged as important alternative to synthetic dyes. There is a report on use of petal part of the saffron flower to extract dye for application on the Pashmina shawl [23]. The potential use of Hibiscus as a natural dye in textile coloration has been reported [24]. The extraction of dyes from floral wastes is represented in Fig. 6. The main advantage of floral dyes is that they are very eco-friendly and have no allergic action on skin. Also, flowers are cultivated widely; easily available and inexpensive, which facilitates their use for dyeing paper at the level of small and medium enterprises as well as larger commercial scale. There is a report where patuletin dye extracted from marigold (*Tagetes erecta* L) and French marigold floral wastes (*Tagetes patula* L) is used in textile industries and also in antioxidant treatment [25]. Flowers have colours due to carotenoids, betalains and anthocyanins [26]. Antioxidant and radical scavenging activity of betalains shows its future use in medicine [27, 28]. Safflower pigments viz. red (carthamin) and yellow (carthamidin) are used as material for dye

Table 3 Amount of biogas kg^{-1} substrate from flower wastes in Kenya. *Source*: [18]

Substrate	Biogas (kg^{-1} substrate)
African wattle	10.92
Roselle	5.18
Nile tulip flower	5.38
Silk tree mimosa	23.73
Sunset flower	2.73
Jasmine	6.07

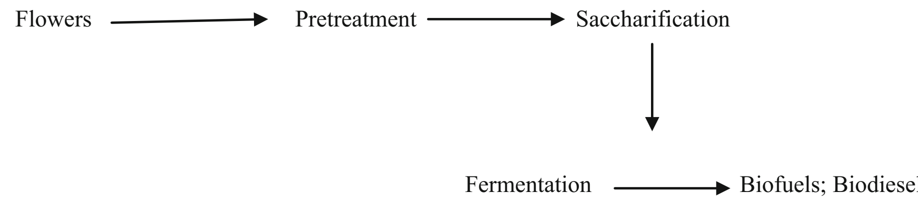

Fig. 5 Flow diagram representing flower as fermentable substrate in fermentation for biofuels and biodiesel production

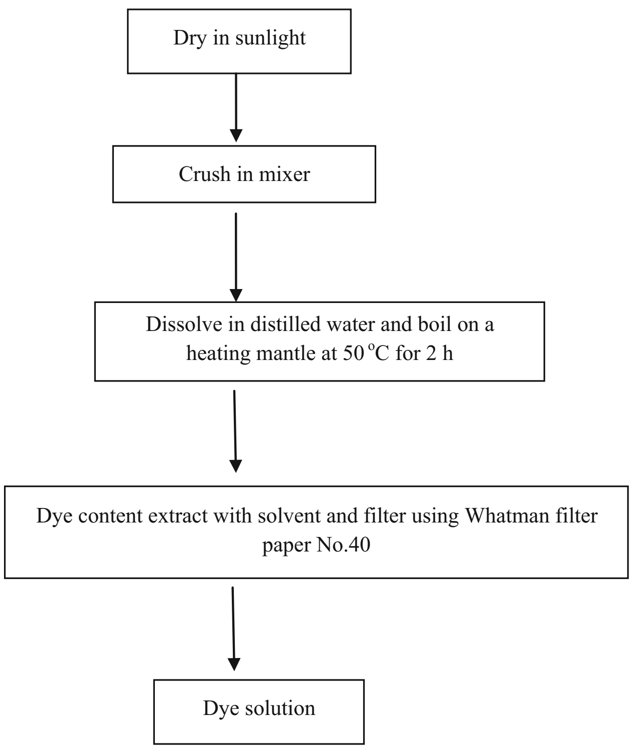

Fig. 6 Extraction of dye from floral wastes

(textile coloration). Safflower petals contain about 30% yellow and 0.83% red pigment [29, 30]. These pigments are widely used as stain, additive in beverages and cosmetics, printing, dyeing and as natural food colorant [31]. The carthamidin pigment is used in preparation of ice creams and also many other food products. African marigold (*Tagetes erecta* L.), a major source of carotenoids and lutein, is grown as a cut flower and a garden flower, in addition to being grown for its medicinal values. Marigold flowers (*Tagetes*), which are yellow to orange red in color, are a rich source of lutein, a carotenoid pigment. Nowadays, lutein is becoming an increasingly popular active ingredient used in the food industry and textile coloration [32]. This pigment has acquired greater significance because of its excellent color value. Although marigold flower extract has been used in veterinary feeds, the potential use of marigold as a natural textile colorant has not been exploited to its full extent which is due to the lack of information on its safety, stability, and compatibility in textile coloration. The natural pigmentation of poultry (broilers, in particular) is affected by the composition especially the carotenoid content of their diet. Extract of marigold flowers is used commercially as an additive to poultry feed to improve the bird and egg yolk pigmentation [33]. Carotenoids, in particular the xanthophylls, lutein and zeaxanthin are the compounds of interest in the marigold flower extract for poultry pigmentation [34]. There is a report on utilization of waste flower *Tagetus erecta* for dyeing of cotton, wool and silk on industrial scale [35]. There is also a report on xanthophylls extracted from fermented African marigold flowers, where xanthophylls yield of 17.8 g kg^{-1} dry weight and 65% efficiency were obtained [36].

Polyhydroxybutyrate-*co*-hydroxyvalerate Production

Sugars such as sucrose and glucose are the most common carbon sources used for polyhydroxybutyrate-*co*-hydroxyvalerate production. Composition of the carbon substrate used for fermentation and utilization of bacterial strain controls the copolymer production where substrate represents nearly 40% of total cost. So, as alternate to this, mahua flower extract is used for polyhydroxybutyrate-*co*-hydroxyvalerate production which is a very cheap carbon source. There is a report on the bacterial synthesis of poly (hydroxybutyrate-*co*-hydroxyvalerate) using carbohydrate rich mahua (*Madhuca* sp.) flowers where mahua flower was found to be cheaper carbon substrate and can be used for the production of polyhydroxyalkonate [37].

Food Products

The extract of Mahua flowers is used in food industries for making jams, jellies, biscuits and other food products due to its nutritional components viz., vitamins, sugars, amino acids, organic acids, enzymes viz., protease and other compounds (betaine, tannins and crude pigments) and antioxidant activity [37, 38]. Figure 7 represents the flow diagram for the bakery products; jam and beverages from mahua flowers. Marigold flowers are natural source of xanthophylls and its extract is used as an additive in many of the food industries.

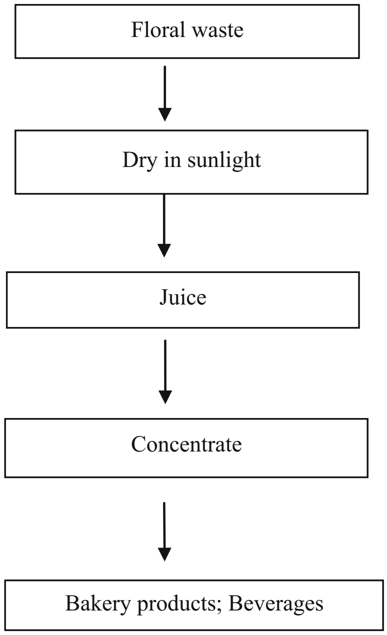

Fig. 7 Flow diagram for the bakery products and beverages from mahua flowers

Sugar Syrup

There are reports on preparation of sugar syrup from dry mahua flowers [39–42]. The production of sugar syrup from floral waste is represented in Fig. 8.

Other Applications of Floral Wastes

Biosurfactant Production

Study has been done on biosurfactant production by *Microbispora* V2 with *Madhuca latifola* flower extract medium having 20 μg mL^{-1} of anthracene. The biosurfactants have strong antibacterial, antifungal and antivirus activity and also play the role of antiadhesive agents to pathogens making them useful for treating many diseases as well as its use as therapeutic and probiotic agent [43]. The production of surface active compounds by *Microbispora* sp. V2 using flower extract of *Madhuca latifolia* L has been studied [44] where the surface active compound produced possessed biosurfactant properties. The cell free supernatants of *Madhuca latifolia* flower extract medium with 20 μg ml^{-1} of anthracene reduced the surface tension to 35%. The glycoprotein biosurfacant possessed good wetting ability and also showed strong antibacterial, antifungal and antivirus activity. The study showed that use of *Madhuca latifolia* L. flowers can be potential bioresource for production of exoploysaccharides having surface active properties [44].

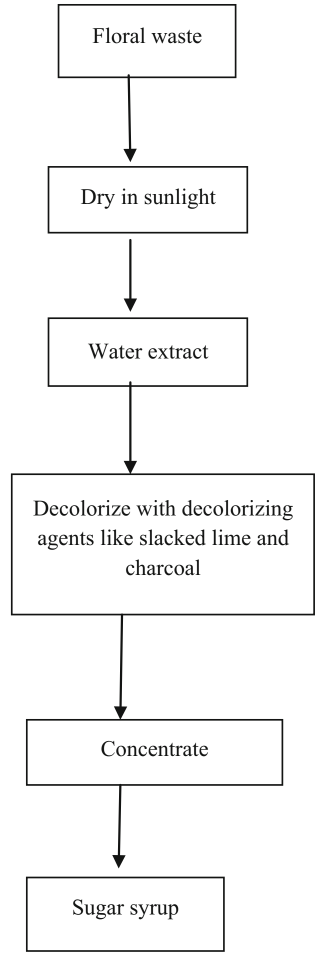

Fig. 8 Production of sugar syrup from floral waste

Medicinal Value of Flowers

Madhuca flowers are used in the treatment of bronchitis and also to increase the milk production in feeding mothers [45]. The calendula oil (olive oil infused with dried calendula flowers) is a good source of massage oil, which is a value added product. Passionflower helps to alleviate anxiety, stress and insomnia; Lily to cure jaundice, respiratory and gastro intestinal disorders and Rhododendron flower juice is used to control high blood pressure. Chamomile essential oil is used for healing of skin disorders like eczema and also to relieve muscular cramps. In most parts of India, rose flowers throughout the year, in a succession of flushes of blooms, without having any true dormant period. There is a great scope for commercial cultivation of rose for production of floral extracts. About 80% of rose flower are utilized for rose water, 10% for attar, 1–2% for pankhuri and remaining for manufacture of gul-rohan and gulkand. Rose oil is used primarily as a fragrance component for pharmaceutical preparations viz., ointments and lotions and is extensively used as a fragrance

Table 4 Application of floral waste in biosorption studies

Name of flower	Scientific name	Applications	References
Carnation, rose and daisy	*Dianthus caryophyllus* *Rosa damascena* *Bellis perennis*	Biosorption of acid blue 9	Echavarria-Alvarez and Hormaza Anaguano[54]
Red rose	*Rosa gruss*	Biosorption of Pb(II) and Co(II)	Bhatti et al. [55]
Biomass derived after color extraction of flower	*Canna indica* *Portulaca olecera* *Hibiscus rosa sinensis*	Removal of chromium(VI) from aqueous phase	Vankar et al. [56]
Medlar male flower	*Mespilus germanica*	Biosorption of nickel	Chergui et al. [59]
Palm flower	*Borassus aethiopum*	Sorption of Cr(VI) and Cr(III)	Elangovon et al. [60]

ingredient in perfumes, creams and soaps. Gulkand prepared from crushed rose flowers is consumed as tonic and medicine for various ailments. *Arnica montana L.* is used in traditional and homeopathic medicine [46], and is believed to have antiseptic, antiphlogistic, analgesic, and anti-inflammatory properties [47]. The extract of the plant is used in liniments [47], and as a topical counterirritant [48]. Saffron petals contain anthocyanin pigments which belong to a parent class of molecules called flavonoids. Phenolic compounds, which include flavonoids and anthocyanins, are mainly associated with health benefits for humans and animals. The antioxidant and antimicrobial properties of saffron have been noticed in recent years. The beneficial effects derived from phenolic compounds have been attributed to their antioxidant activity. Antioxidant properties of pigments in flowers like carotenoid, betalain and anthocyanins leads to its applicability in treating human cancer [27, 49, 50].

Incense Sticks and Rose Water Using Floral Wastes

Methods have been developed to make herbal incense sticks using floral wastes. Flowers like *Genda* are used to make incense sticks, while roses are converted to rose water. In Lucknow at Kathwara village the Chandrika devi temple, huge quantity of flowers is offered to the deity everyday. The womenfolk use these floral waste to make incense sticks and sell to the small time retailers in the village markets, which becomes a source of income for them.

Floral Waste as Source of Raw Material for Handmade Paper Production

Flower waste management from temples can serve as a sustainable source of raw material for handmade paper production [51]. This method not only reduces the generally discarded waste produced by city temples, but also recycles and reuses it as an environment friendly paper. The handmade paper made from flower waste has many advantages viz., 100% free from wood and all chemicals; leaves no harmful by-products during the manufacturing [52]. Hence, the concept of reduce; reuse and recycle which is important can be implemented in handmade paper making. Also, the problem of disposing the floral wastes can be solved.

Application of Floral Wastes in Biosorption Studies

Heavy metals are extensively used in industries like electroplating, paint pigments, steel works, electrical accumulators, batteries, etc. These metals cannot be degraded biologically into harmless products and are mostly disposed in water [57]. Biosorption is a attractive technology for removal of heavy metal ions which utilizes low-cost biosorbents [58]. The application of floral waste in biosorption is represented in Table 4.

Conclusions

The review describes the management of floral wastes by conversion into different value-added products viz., compost; biofuels; biogas; bioethanol; organic acids; pigments; dyes; polyhydroxybutyrate-*co*-hydroxyvalerate production; food products; biosurfactants production; sugar syrup. The floral waste also have other applications viz., making of incense sticks; handmade paper production; etc. The value-added products obtained from floral wastes viz; compost can be used for various plant growth; biogas for electricity generation; food products as nutrients and additives. The dyes and pigments from floral wastes will have applications in various textile industries; while biofuels and bioethanol can solve the problem of energy crisis. The waste can thus be converted into wealth. The floral wastes can have important application in biosorption which will help in the treatment of waste waters and other industrial effluents. This will resolve the problems of disposal of floral waste and ultimately the water and environmental pollution will also be reduced. Further research should be carried out for the conversion of waste flowers into wealth. Novel approaches should be investigated for use of organic waste. Bioremediation of floral wastes are of high importance. The significance of the review is that it describes management of floral waste and also how the waste can be converted to wealth. The significance The exploitation of the floral waste will have benefit in bioeconomy as the floral waste will be converted to different value-added products which will have different applications.

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