ISSN: 3064-9846
Research Article

Journal of Agricultural, Earth and Environmental Sciences

Extraction of Essential Oil from Marigold Targets Erecta l., an Economical and Eco-Friendly Approach to Floral Waste Management with Cost Analysis

Praveen Soni, Anish P Jacob*, Ishita Pant, & Avinash Pali

Department of Chemical Engineering, Madhav Institute of Technology & Science Gwalior-474005(M.P.), India

***Corresponding author:** Anish P Jacob, Department of Chemical Engineering, Madhav Institute of Technology & Science Gwalior-474005(M.P.), India.

Submitted: 02 January 2025 **Accepted:** 09 January 2025 **Published:** 16 January 2025

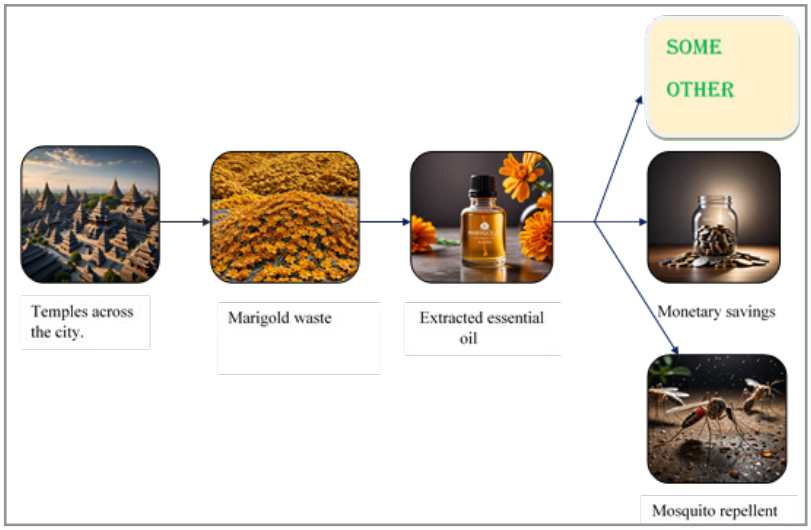
https://doi.org/10.63620/MKJAEES.2025.1069

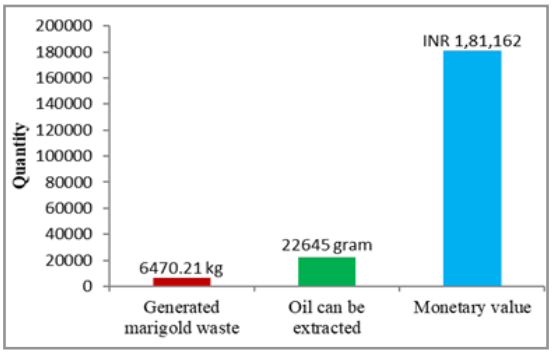
Citation: *Soni, P., Jacob, A. P., Pant, I., & Pali, A. (2025). Extraction of Essential Oil from Marigold Targets Erecta l., an Economical and Eco-Friendly Approach to Floral Waste Management with Cost Analysis. J of Agri Earth & Environmental Sciences, 4(1), 01-06.*

Abstract

According to the current scenario in India, waste flowers generated from temples are being directly disposed in nearby water bodies or dumped at one place for decomposition. Of all floral waste, marigold flowers are commonly used for offering and decorating temples. These practices of floral waste disposal pose a remarkable challenge to existing waste management. There have been many studies regarding the disposal of floral waste; however instead of direct disposal, there is still vast scope for using these waste flowers. The major use of this waste marigold can be carried out in the form of essential oil extraction. Waste flowers from the temples are collected and then, using a hydro- distillation approach, oil is extracted. The yield of oil obtained from these waste marigolds was compared with that of fresh marigold flowers. Cost analysis conducted to check whether the approach is cost effective. On a normal day, 22.645 kg of essential oil per day can be extracted within a Hyderabad city, India. The yield of oil obtained is 0.349% per kg of marigold. The percentage savings obtained from presented study for Hyderabad city is 72.53 which in itself is a big number. With the help of this study one can clarify the applicability of similar approach to their location. Production of oil from marigold waste is economical and sustainable. This essential oil has various uses such as mosquito repellents. The major concern is to make the whole process environmentally friendly. In addition to the other direct benefits, it provides new employment opportunities to the people, which will be a better asset to India's GDP growth.

Graphical Abstract





Keywords: Hydrodistillation, Anti-inflammatory, Monetary Savings, Vapourizer, Repellent

Abbreviations

- **GE:** Kilogram of CO2
- **KWH:** Kilowatt hours (unit of power)
- **MY:** Percentage of mass yield
- **WM:** Total marigold waste in kg

Introduction

India is a country of religions and offering flowers in spiritual places is a congenital trait of Indian culture [1, 2]. Varanasi (India), for example, although being one of the revered cities in the world, has need of a well-managed system for safely disposing of vast amounts of trash. In this holy city, 3500 to 4000 kg of material is discarded as rubbish Temples in Chitrakoot are also noted for producing a lot of floral waste [3]. Many people offer flowers to Chitrakoot temples on a daily basis. Flowers are disposed in two locations: one on the Ramghat on the Mandakini River's bank, and the other on Lord Kamtanathji's platform. Approximately it is 5.48 tonnes per year. Floral debris is produced in both locations [4]. Every day, these flowers are offered by devotees in the temples, are left after 'Pooja' and therefore become waste. In India, festivals are celebrated throughout the year such as Durga Pooja, Diwali, Janmastmi, Ganesh utsav, etc, which ultimately lead to the generation of solid waste in huge quantities. In India, a considerable quantity of flowers, such as roses, marigolds, and carnations, are incorrectly disposed at various religious sites, banquet venues, and other festivals [4]. These flowers are either dumped into the river or thrown in land, causing adverse effects on the river ecology and presenting foul smell from the disposal sites. There are already existing different methods for handling floral waste, but if there is a possibility to utilize this waste and obtain monetary value, which would indirectly be a positive asset to India's GDP growth, then why should one not think about this idea? It has been often observed that in almost all temples, the percentage of marigold flowers in the waste is more than that of other kinds of flowers .This study is presented for the Hyderabad city .The flower samples were collected from GHMC zones (con GHMC zones, namely L.B. Nagar (East-Zone), Charminar (South-Zone), Khairatabad (Central-Zone), Secunderabad (Northeast-Zone),Serilingampally (West-Zone), Kukatpally (North-Zone) during the year 2021) consisting of 5 temples. As compared to other flowers, marigold quantity was larger [5]. Flowers that have withered and dried are disposed of as rubbish in landfills, different bodies of water etc. examples of nations where almost 40% of the world's flower production goes to waste every day are Srilanka and India [1]. Decomposition generates greenhouse gases such as carbon dioxide (CO2) and methane (CH4) which is harmful for the environment [6].

Marigold is an ornamental flowering plant of the Asteraceae-and, Asteroideae subfamily of the Tagetes genus. It consists of more than 30 species from around the world, which can be both annual and perennial [7]. In India, the variety of marigold that is mainly found is Tagetes erecta L. (Asteraceae). There are different ways to extract essential oil from marigold such as hydrodistillation (HD), cold expression, steam distillation, solvent extraction, maceration, pressure swing distillation, and empyreumatic (or destructive) [7]. Out of all these methods, the hyrodistillation approach is mainly used in industries. The yield of the hydro-distilled oil in different plant parts ranged from 0.65%–0.70% on fresh weight basis while another study showed that the percentage yield of yellow and orange marigold is 0.35% and 0.43%, respectively (orange is slightly higher than yellow - around 0.08%) [8, 9]. There are a variety of uses for this extracted essential oil, like such as insecticides, nemacides, and mosquito repellents. These are the important factors that reflect, these flowers can be re-used in the form of essential oil. Here in this study use of essential oil has been signified as a mosquito repellent [10]. The smell is caused by a chemical compound present in the oil is 'a-terthienyl', which lends a natural insecticidal property to marigold. The test was performed in a glass box of cuboidal shape with an opening so that mosquitoes could escape through [11].

Twenty main components were tabulated here for both yellow and orange marigold with 97.3% and 96.6%, respectively. The main component for both yellow and orange was piperitone (a monoterpene Ketone), with relative concentrations of 26.9% and 31.5% [9]. Composting is a safe way of managing organic wastes, but it is associated with odor production and release of greenhouse gases (CO2, SO2, and NO2) [12]. White marigold Chrysanthemum morifolium was recovered in bulk from market waste streams and was thermally processed into valuable low-cost biochar. The products were synthesized by pyrolysis under slow thermal carbonization conditions at 350 °C and 500 °C [13]. A novel approach has also been presented to floriculture by sustainable management of SS which reduced the public health and environmental impacts [14]. Flowers waste can be recycled into organic manure which is important and strong alternative to chemical fertilizers for a sustainable development in agriculture [15]. Floral wastes can be used in the form of different value added products such as compost;biofuel, biogas; bioethanol; organic acids; pigments; dyes; polyhydroxybutryrate-co-hydroxyvalerate production; sugar syrup [20]. The important components of essential oils from the leaves and flowers of Tagetes erecta L. grown in Nigeria were examined by GC and GC/MS are Piperitone (50.7%), piperitenone (13.2%) and (E)-β-ocimene (6.7%) [16]. In order to be used in breeding purpose, Tagets species were additionally described for a variety of features, including essential oils, carotenoid pigments, thiophenes, traits linked to flower yield traits connected to biotic and biotic stress etc. [17]. Molecular analysis was done for Tagets erecta apetala2 in flower development and found it is transcript factor associated with meristem determination [18]. Activity and recovery vs extraction time for Tagets erecta, Tagets patula and Tagets minuta were found by soxhlet and simultaneous distillation extraction method using methylene chloride. It was noted that extraction time of ten hour resulted in highest activity and 90% recovery of the oils [19]. When marigold flowers were pre-treated with sodium hydroxide citric acid and then hydraulically pressed, the amount of water significantly decreased and the dry yield, resin yield and the pigment yield were all enhanced over the control sample [20]. Marigold is used as a natural textile colour because it contains carotenoid.This carotenoid is extracted with the help of ethanol [21]. Tagets erecta plant shows tendency to absorb heavy metals. Experiment was conducted and found that overall uptake capacity for plant's different part was in order of Pb>Ni>Cr [22]. The biggest challenge to produce energy from waste materials in developing nations, however, is the high establishment charge of the systems [23].

To perform this work marigold flowers has separated from other wastes collected from temples. Then, following hydro distillation approach, essential oil is collected. After collection of essential oil yield has been calculated and then considering Hyderabad city as the basis, whole mass balance has been applied with cost analysis. The major intent of this study is to make the process completely environment friendly with zero carbon emissions, so tools and processes have been implemented accordingly. For water prices in the study, cost is calculated using data available from "Industrial Water Demand in India – Challenges and Implications for Water Pricing" [24]. India is a large country and offering flowers is common practice and it would be long for many decades, so using these wastes will be quite beneficial in all aspects.

Materials and Methods

The hydrodistillation method has been used for extracting essential oils [25].

Requirements: Marigold waste petals collected from temples (300 gram), distillation setup, electric heater (1100 W), distilled water (500 ml), chilled water (10-12 L), separating funnel.

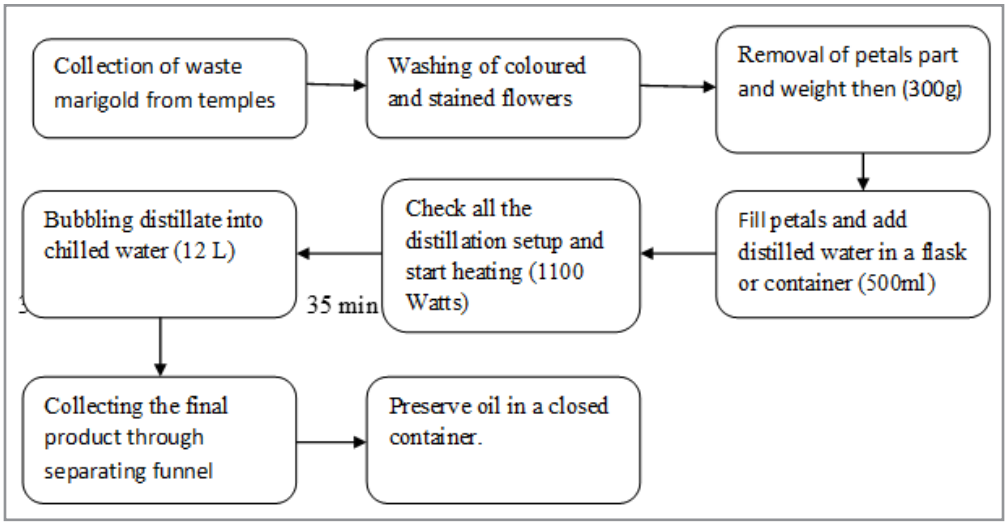


Figure 1: Flow chart of the Process Used

Pictures of the performed experiment

Figure 2: Pictures Showing the Process Undertaken during Experiment

The experiment was performed three times to ensure the accuracy of the results and increase the reproducibility of the data. The experiment is reliable on a large scale and follows the basic principle of oil extraction.

Economic and Environmental Impact Analysis

Cost components

As per the rating of heater -1100 watts and 35 minutes, the units of electricity consumed is 0.641 (KWH). According to the tariff scheme LV-4 (Industrial plant) 2023-24 ;1-unit (KWH) costs Rs. 6.60. So, its cost will be: Rs .4.235 Pure water cost Rs. 0.698 (cost included according to industrial price [24])
Total cost = Rs. 4.933 ~ 5.

Yield calculation

Mass of oil collected = 1.05gram
Petals of flower = 300gram

% Mass yield = (kg of oil collected)/(kg of flowers petals)*100

MY = (0.00105/0.300) *100
MY = 0.349 %

Fresh flower scenario [9]

The percentage yields of yellow and orange marigold are 0.35% and 0.43%, respectively

Savings calculation

As per the available market price, the cost of 1 kg of marigold essential oil is Rs. 8000/-
So, the extracted oil be of Rs. 8.4
% savings =((8.4-5)/5)*100= 68%
Saving is found to be 68%.

Environmental Impact

Indirect carbon emission according to the guidelines of ISO14064LCA
Kg of CO2 = 0.85*(KWH consumption). This study used 0.641 units of electricity.
So,
GE = 0.85*0.641
GE=0.544 kg CO2.
This quantity of gases has been produced.

Scale-up Approach

Considering Hyderabad city as a basis, the average waste marigold generated from temples = 3.67 kg/day/temple [26]. There are 1763 Hindu temples in Hyderabad city as of September 24 ,2023. So according to that total marigold flower wasted from the whole city
WM = 3.67*1763
WM= 6470.21 kg/day
Electricity cost = INR 4000
Water cost = 6470.21*1.01*1.607 = 10892
= INR 11000

No. of units to be installed in the city = 5 (These units will be distributed in entire Hyderabad city in such a way that it would cover maximum the nearby temples).

Other costs will include transportation, labour etc.

No. of labours = 10 per unit
No. of operating engineers = 2 per unit
Extra man power = 5 per unit
Daily wages of labours = INR 450/per day
Engineer payment = INR 1000/per day
Extra men power wages = INR 300 per day
Total labour cost for all 5 unit will become = INR 40000/-

Transportation charges will depend upon the distance and daily fuel prices.

For study estimation maximum daily transportation cost = INR 40000
Other extra cost = INR 10000
Total Investment = INR 105000
This waste flower based on this study obtained yield can produce 22.645 kg per day of essential oils.
Its market cost based on current prices will be Rs.1,81,160.00/ per day.
% savings =((181160-105000)/105000)*100= 72.53.

Alternate to an Electrical Source

Carbon dioxide generated = 606.06*0.85=515.151 kg of CO2

The electricity components used in the study produce carbon dioxide, which is responsible for global warming; therefore, in order to reduce carbon footprints equivalent order of trees will be planted and also use of solar heater should be promoted. This solar heater is highly appropriate to make process pollution free. It would also be highly beneficial to spread solar technology around the different locations.

Residue Treatment

After extraction of oil, the general question comes is how can residue be treated. Is it safe to decompose or not? This residue can be treated as a substrate for vermicomposting.This is suitable a technique for reducing solid waste pollution[9].The main advantage of vermicomposting is that it is one of the eco-friendly technologies because it overcomes the problem of organic waste disposal and alleviates the odor problem.[27] Vermicomposting also cleans the environment and provide renumerative organic manure. The vermicompost obtained was rich in carbon (28%), nitrogen (1.58%) etc. [28, 29]. The antioxidant properties of cultivated marigold found; 0.75 mg/ml extracts completely eliminated hydroxyl radical which was generated in Fenton system [30]. The residue also includes lutein, a carotenoid pigment that is decomposable under light and heat. Its significant degradation was found between 50oC-60oC [31]. This lutein can also be extracted using dimethyl ether.

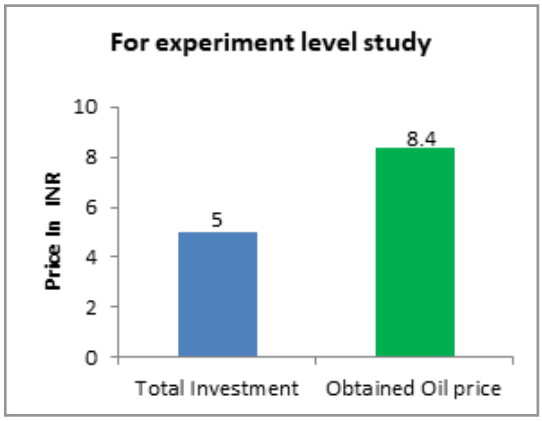
Mosquito Repellent

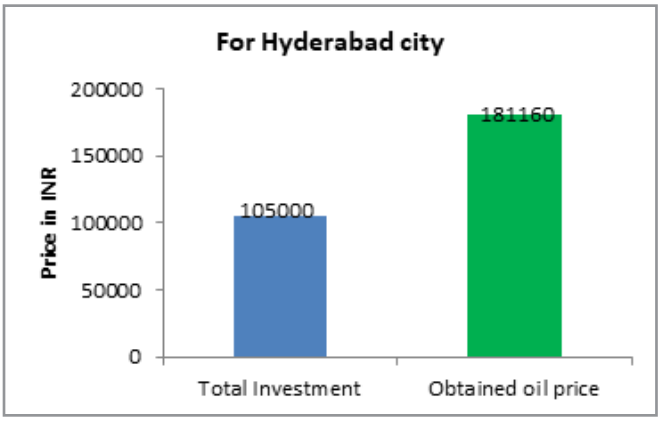
The entire marigold plant has been considered to have insecticidal properties. With this aspect, the extracted oil from marigold has been used in the present study to prepare mosquito electric vapourizer. It contains a particular smell that many insects find awful. The smell is caused by a chemical known as “a-terthienyl”. This lends a natural insecticidal property in marigold.

Many tested have already been performed to check the mosquito repellency of the marigold flower [11]. One can use it by directly rubbing some Tagetes Oil onto your skin. It’ll keep mosquitos and other pesky bugs at bay. However, in order to make its use in

room and convenient, it can be used as an electric diffuser with some carrier oil such as lavender oil and sandalwood aroma oil. This extracted oil diffuser should be available at a reliable price so that a common people can also be able to use it. This will be a major advantage of waste marigold because mosquitoes frequently cause malaria to people, in rural areas, due to improper waste water treatment.

Results and Discussions





The present study clearly shows that there is approximately the same yield percentage of 0.35% of extracted oil from fresh and waste collected marigold. Waste marigold should not be older than a day and proper pre-treatment such as separation and, washing is required. Similarity in repeated experiment results shows that this process can be scaled up. Standard parameters are used to conduct an economic analysis, which depicts 68% monetary saving on experimental scale. The mass balance has provided 22.645 kg per day marigold essential oil can be collected from Hyderabad city based on the marigold waste quantity from the total no. of temples, this much quantity of oil presents a cost of approximately Rs.1,81,160.00/- per day, which is really a significant amount for any project. The project has saved 76,160, which is a substantial sum that demonstrates its economic viability. The whole process can be made zero pollution by using solar heater in place of electric heater so further environmental impact cost will get ended. Residue obtained after extraction are also compostable and can be used as manure supplement in biogas plant which were already in practice of using whole waste marigold. The new approach that has been revealed by present study about using essential oil as mosquito repellent in electric vaporizer will be revolutionary step for the rural people. Along with these benefits, this idea offers employment opportunities to skilled as well as local people, will prove a trump card for the Indian economy.

Conclusion

In India, the practice of flowers offering flowers will never be replenished, so floral waste will continue to be generated from the temples. The present disposal methods don't make efficient use of these huge quantity wastes. Marigold is one of the important components of these floral wastes. The quantity of marigold waste in Hyderabad city is 6470.21 kg/day, which itself presents a large amount. If this is the case of only one city of India then what would be the figure for all the cities. According to that much quantity the per day monetary benefits will become very high and in that case this oil can be easily accessible to majority of people around the country. This oil offers several benefits like anti-inflammatory properties, improves respiratory function, antibacterial properties and mosquito repellents. In this way country's people health scenario will improve. The present study proves this process economical and environment friendly by performing experiments on small scale but multiple times. Finally waste marigold can become boon to India's economy.

Acknowledgement

The authors acknowledge to the department of Chemical Engineering and laboratories where all the experiments were performed.

Competing Interest

The author declares that they have no competing interest.

Data Availability

All the materials used during this study are available from the author upon reasonable request.

Funding

There was no funding agency for current research.

References

1. Masure, P., & Patil, B. (2014). Extraction of flower wastes. International Journal of Engineering Research & Technology, 3(11), 43-44.
2. Jadhav, A. R., Chitanand, M. P., & Shete, H. G. (2013). Flower waste degradation using microbial consortium. IOSR Journal of Agriculture and Veterinary Science, 3(5), 1-63.
3. Mishra, R. K., Mohanty, K., & Wang, X. (2020). Pyrolysis kinetic behavior and Py-GC–MS analysis of waste dahlia flowers into renewable fuel and value-added chemicals. Fuel, 260, 116338.
4. Waghmode, M. S., Gunjal, A. B., Nawani, N. N., & Patil, N. N. (2018). Management of floral waste by conversion to value-added products and their other applications. Waste and Biomass Valorization, 9, 33-43.

5. Kumar, S. (2020). Review on marigold extract for disease management. International Journal of Current Microbiology and Applied Sciences, Special Issue-11, 3527-3534.
6. Kumar, A., & Samadder, S. R. (2017). A review on technological options of waste to energy for effective management of municipal solid waste. Waste Management, 69, 407-422.
7. Tiwari, A., Goswami, P., Bisht, B. S., Chauhan, A., Verma, R. S., & Padalia, R. C. (2016). Essential oil composition of African marigold (Tagetes minuta L.) harvested at different growth stages in foothills agroclimatic conditions of North India. Am. J. Essent. Oils Nat. Prod, 4(3), 04-07.
8. Brijesh Tripathi, B. T., Rohit Bhatia, R. B., Suresh Walia, S. W., & Birendra Kumar, B. K. (2012). Chemical composition and evaluation of Tagetes erecta (var. Pusa Narangi Genda) essential oil for its antioxidant and antimicrobial activity.
9. Das, S. C., Hossain, M., Jahan, N., & Uddin, M. A. Chemical Analysis of Essential Oil Extracted from Tagetes Erecta L. Sourced from Bangladesh.
10. Kumar, A., Dunkel, F. V., Broughton, M. J., & Sriharan, S. (2000). Effect of root extracts of Mexican marigold, Tagetes minuta (Asterales: Asteraceae), on six nontarget aquatic macroinvertebrates. Environmental entomology, 29(2), 140-149.
11. Ponkiya, N., Desai, S., Mistry, J., Patel, S., & Ingalhalli, R. (2018). Development of economical mosquito repellent using marigold plant. Int. J. Res. Trends Innov, 3, 47-54.
12. Ayilara, M. S., Olanrewaju, O. S., Babalola, O. O., & Odeyemi, O. (2020). Waste management through composting: Challenges and potentials. Sustainability, 12(11), 4456.
13. Panditha, T. S., Sudalai, S., & Arumugam, A. (2021). Renovation of waste Chrysanthemum morifolium (Marigold) into valuable biochar: A study on the utilization of solid waste by pyrolysis. Journal of The Institution of Engineers (India): Series E, 102, 239-248.
14. Al-Huqail, A. A., Kumar, P., Abou Fayssal, S., Adelodun, B., Širić, I., Goala, M., ... & Eid, E. M. (2023). Sustainable use of sewage sludge for marigold (Tagetes erecta L.) cultivation: experimental and predictive modeling studies on heavy metal accumulation. Horticulturae, 9(4), 447.
15. Swapna, P., & Lakshmi, V. V. (2020). Effective Recycling of Flower Waste as Organic Manure. Bioresource Utilization and Bioprocess, 253-265.
16. Ogunwande, I. A., & Olawore, N. O. (2006). The essential oil from the leaves and flowers of "African Marigold," Tagetes erecta L. Journal of Essential Oil Research, 18(4), 366-368.
17. Gupta, Y. C., Panwar, S., Banyal, N., Thakur, N., & Dhiman, M. R. (2022). Marigold. In Floriculture and Ornamental Plants (pp. 1-23). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-15-3518-5_1.
18. Alegría-Mundo, H., Yong, L., Cruz-Ramírez, A., Herrera-Estrella, L., & Cruz-Hernández, A. (2010, August). Molecular analysis of marigold (Tagetes erecta) apetala2 in flower development. In XXVIII International Horticultural Congress on Science and Horticulture for People (IHC2010): International Symposium on 929 (pp. 293-298).
19. Wells, C., Bertsch, W., & Perich, M. (1992). Isolation of volatiles with insecticidal properties from the genus Tagetes (marigold). Chromatographia, 34, 241-248.
20. Sowbhagya, H. B., Sushma, S. B., Rastogi, N. K., & Naidu, M. M. (2013). Effect of pretreatments on extraction of pigment from marigold flower. Journal of food science and technology, 50, 122-128.
21. Vankar, P. S. (2009). Utilization of Temple waste flower-Tagetus erecta for Dyeing of Cotton, Wool and Silk on Industrial scale. Journal of textile and Apparel, Technology and Management, 6(1).
22. Fatima, A., Farid, M., Asam, Z. U. Z., Zubair, M., Farid, S., Abbas, M., ... & Ali, S. (2023). Efficacy of marigold (Tagetes erecta L.) for the treatment of tannery and surgical industry wastewater under citric acid amendment: a lab scale study. Environmental Science and Pollution Research, 30(15), 43403-43418.
23. Sharma, D., Yadav, K. D., & Kumar, S. (2018). Role of sawdust and cow dung on compost maturity during rotary drum composting of flower waste. Bioresource technology, 264, 285-289.
24. Aggarwal, S. C., & Kumar, S. (2011). Industrial water demand in India: Challenges and implications for water pricing. India Infrastruct. Rep, 274-284.
25. Kumar, R., & Tripathi, Y. C. (2011). Getting fragrance from plants. Training manual on extraction technology of natural dyes & aroma therapy and cultivation value addition of medicinal plants, 1, 77-102.
26. Sri Soundarya, S., Radhika, P., Srinivasa Reddy, D., & Supriya, K. (2021). An Analysis of Pattern of Floral Waste Generated and Disposal in Hyderabad City of Telangana State.
27. Shadanpour, F., MOHAMMADI, T. A., & HASHEMI, M. K. (2011). Marigold: The possibilty using vermicompost as the growth medium.
28. Shouche, S., Pandey, A., & Bhati, P. (2011). Study about the changes in physical parameters during vermicomposting of floral wastes. Journal of environmental research and development, 6(1), 63-68.
29. Sailaja, D., Srilakshmi, P., Shehanaaz, P. H., Bharathi, D. L., & Begum, A. (2013). Preparation of vermicompost from temple waste flower. Int J Sci Inno Discov, 3(3), 367-375.
30. Ćetković, G. S., Djilas, S. M., Čanadanović-Brunet, J. M., & Tumbas, V. T. (2004). Antioxidant properties of marigold extracts. Food Research International, 37(7), 643-650.
31. Manupa, W., Wongthanyakram, J., Jeencham, R., & Sutheerawattananonda, M. (2023). Storage stability and antioxidant activities of lutein extracted from yellow silk cocoons (Bombyx mori) in Thailand. Heliyon, 9(6).