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### Sustainable method for bioremediation of temple floral waste into compost

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#### Abstract

The present study was undertaken to initiate a path of converting the temple floral waste (FW) into compost. Large quantities of flowers are offered daily in many religious places. The flowers are prone to microbial attack due to low shelf life and high moisture content in them. Many value added products like incense sticks, cones, perfumes, natural dyes, essential oils etc are produced from floral waste. But because of quality of flower received as a waste to make these value-added products is not good, many times the product quality is compromised. The best method for this type of floral waste would be to convert them into compost, which can be used as a biofertilizer. This will add nourishment to the soil making it nutrient rich.

Fungi are known to be the havoc in plants by inducing plant diseases, but some fungi are known to be the growth inducers in plants. *Trichoderma* is one of the fungi that have growth inducing effects too. In the present study *Trichoderma* cultured on wheat grains, used as inoculums taken up for experiments with floral waste to convert it into compost with the help of fungal inoculation. The results demonstrated that inoculation of fungi with waste turns the waste to degrade rapidly, achieving faster compost preparation. The OC level also changes significantly indicating the degradation and the germination rate also prove to be effective. Today, in the era of organic food demand, farmers and local business are constantly in requirement of natural fertilizers rather than chemicals. Thus, the compost so prepared in the study can prove to be the effective one for the organic culture.

**Keywords:** Floral waste, *Trichoderma*, compost, fungal biodegradation

#### 1. Introduction

In the whole world, India is country which is famous for its culture and tradition there are different religious people living and celebrating different festivals throughout the year. Many temples, gurdwaras, mosques & church are there in India, more than thousands of people visit them daily or during festivals. Mostly in all holy places flowers are usually offered by devotees to their God & also used for decorating the temples. There is a tradition in India to offer specific flower to specific god. Different types of flowers like; Rose, Hibiscus, Chrysanthemum, Jasmin, Marigold, Tulsi, Banana or Mango leaves etc. are being offered. Every city of India, daily these flowers offered by the devotees in temples are left unused and therefore become waste (Waghmode *et al.*, 2018) <sup>[19]</sup>. Temples are decorated with flowers of different kinds as well as flowers are offered to God & Goddess at the time of puja (Yadav *et al.*, 2015) <sup>[20]</sup>. As offered flowers to God are considered as sacrosanct so they are not thrown with other waste generated in hotels, markets, etc. as it hurts the religious sentiments, therefore, are disposed in water bodies or left in open places (Barad and Upadhyay, 2016) <sup>[3]</sup>. There is no proper disposal management thus causing environmental pollution. Every city of India, daily these flowers offered by the devotees in temples are left unused and therefore become waste. The percentage of flowers sold and unsold and remaining disposed to waterbodies and as garbage is represented in Fig.2 (Waghmode *et al.*, 2018) <sup>[19]</sup>.

Approximately, 1450 tons of floral waste (FW) are generated every day and cause environment pollution (Ravishankar *et. al* 2014) <sup>[11]</sup>. In the cities having many pilgrimage spots produces high amount of waste. It increases more during the festival seasons. Banaras, one of the holiest city of India generates 3.5-4 tons of waste by the temples every day. But it is left behind with no system of disposal in the city (Mishra, 2013). Mishra and Joshi (2002) <sup>[7, 8]</sup> estimated that 1873.7 kg of organic waste was generated every day in Hardwar city. During important six occasions, 20,435 kg solid waste was generated in the year 1997. There is no proper disposal management thus causing environmental pollution. This temple floral waste generally contains biodegradable & non-biodegradable waste as it contains flowers, leaves, fruits, incense sticks, cloths, plastic, etc.

Due to the biodegradable nature of flower waste, it creates a wrong assumption among people that flower waste degrades fast if it is dumped anywhere despite fast decomposition flower waste decomposes very slowly as compared to kitchen waste (Jadhav *et al.*, 2013) <sup>[4]</sup>. It is estimated that nearly 40% of flowers from total production remain unsold and wasted in India and Sri Lanka. Dumping of flower waste on roadsides and open places gives filthy look to an area and distorts the image of an area especially the places that are regarded as important tourist destinations (Waghmode *et al.*, 2018) <sup>[19]</sup>.

Because of the improper disposal of wastes the hazardous

impact can be observed on the environment, so there is need for utilization and management of these floral waste. Improper disposal of floral waste in open landfills may result in various health hazards. After a few days of disposal, microorganisms act upon flower waste to degrade it thereby releasing harmful gases. These gases include methane (CH<sub>4</sub>), carbon dioxide (CO<sub>2</sub>), ammonia (NH<sub>3</sub>) and others which create the foul smell and significant contribution to greenhouse emissions (Singh *et al.*, 2017) [22]. Dumping of flower waste in water body's results in a threat to aquatic environments. The aquatic organisms including fishes, diatoms, protozoans, molluscs plankton diversity are significantly affected by such waste disposal practices (Mahindrakar, 2018) [1].

Increased organic load of the water body by flower waste disposal may tend to grow harmful weeds and microbes which eventually depleting its oxygen levels (Makhania and Upadhyay, 2015) [5]. Flower waste disposed into rivers causes pollution of river water and is also harmful for both human and aquatic life. Thus, owing to the organic nature of flower waste and the significant presence of macro and micronutrients, composting offers a feasible solution to deal with flower waste (Sharma *et al.*, 2017) [13]. Such flower waste can be used in different manners to produce valuable products.

In addition to religious sites, significant amounts of floral waste are generated in residential areas and community centers. The safe disposal of this flower waste is a pressing concern, as it is often carelessly discarded into rivers and oceans, severely impacting the environment. Furthermore, waste from flowers is produced at hotels, wedding venues, and during sacred ceremonies, underscoring the urgent need for effective floral waste management in these areas.

Vadodara (also known as Baroda) is one of the large cities in state of Gujarat. Vadodara is located at 22.30° N 73.19° E in western India at an elevation of 39 metres. It is the 18<sup>th</sup> largest city in India & is located on the bank of Vishwa Mitri River. The Vadodara city generates around 750.00 MT of solid waste per day. The bio-degradable waste is not segregated either at the primary collection points, secondary collection points, or dumping sites. Most of the bio-degradable waste are found to be eaten by animals at the grazing on the open dumping sites. Non-biodegradable wastes are disposed off at the dumping sites along with other wastes without any prior processing (Mewada, 2020) [6].

The present study was initiated by carrying out survey in the temples in and nearby area of Vadodara city to have an idea of the amount of floral waste generated by these temples and its management practices if any. Efforts have been made to degrade the floral waste with microbial consortium with an approach to prepare quality biomanure without causing pollution in the environment.

## Materials and Methods

Vadodara has good number of small and large temples present inside the boundary. Every area has at least one temple or religious place in order to offer prayers by the devotees.

A survey was carried out in and around Vadodara to identify some of the major temples visited by large number of devotees offering flowers to the diety with an aim to

determine the amount of waste generated. The temples with their locations and addresses were listed down and 18 temples of the city were visited and information was gathered from the priests and other temple officials. A questionnaire based survey was carried out further by visiting these selected temples, meeting the pujaris and management committee where possible.

## Source of floral waste

Floral waste generated from Kashiwishwanath temple and Ayyappa temple in Vadodara were collected daily and used in the present study

## Source of fungi

*Trichoderma reesei* a mesophilic, filamentous soil fungus has a long history of safe use in industrial-scale enzyme production. This genera is an important commercial and industrial micro-organism due to its cellulase production ability. *Trichoderma* can produce plant growth stimulators, such as indoleacetic acid (IAA) and harzianolide, to promote the development and growth of plant roots by secreting phytase and ferritin to promote the absorption of P and Fe by plants; decomposes soil organic matter; increases the supply of soil nutrients; improves crop photosynthetic efficiency; improves plant height, stem diameter, and other agronomic traits; and increases production (Lombardi *et al.*, 2020).

The mother cultures of *Trichoderma reesei* were obtained from Seed Anatomy Laboratory, Department of Botany, The Maharaja Sayajirao University of Baroda, Vadodara and used for the experiments performed.

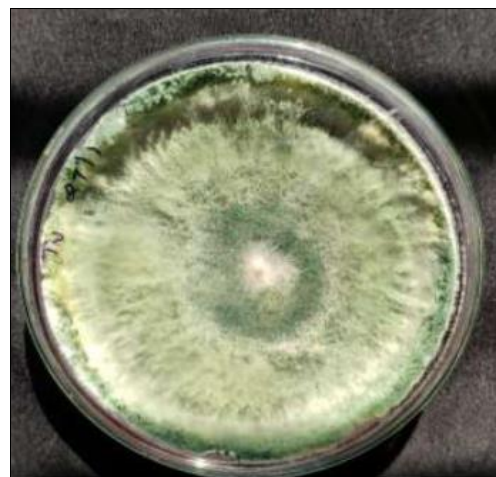


**Fig 1:** Culture of *Trichoderma*

## Sub culturing and characterization of fungi

Inoculum from the mother culture were inoculated on the Potato Dextrose Agar medium (PDA). The media was prepared by taking 6 grams Agar, 4 grams Dextrose, 40 grams potatoes and 200 ml distilled water. It is then autoclaved at 121 °C. The medium was poured into petri dishes (100 × 10 mm) within a certified biosafety cabinet after interior surfaces were sanitized with 70% Ethanol and 10 min of exposure to high intensity UV light. The agar solution was allowed to solidify over 24 hr and used for inoculation.

The activity of fungi is at its peak at 7<sup>th</sup> day of the sub

culturing as exponential phase is attended at 7<sup>th</sup> day. The experiment is further conducted from these cultures (Fig.1) between 7-9 days of sub culturing.

### Preparation of inoculums for degradation experiment

For preparation of inoculum, the fungus from the culture were grown on wheat grains.

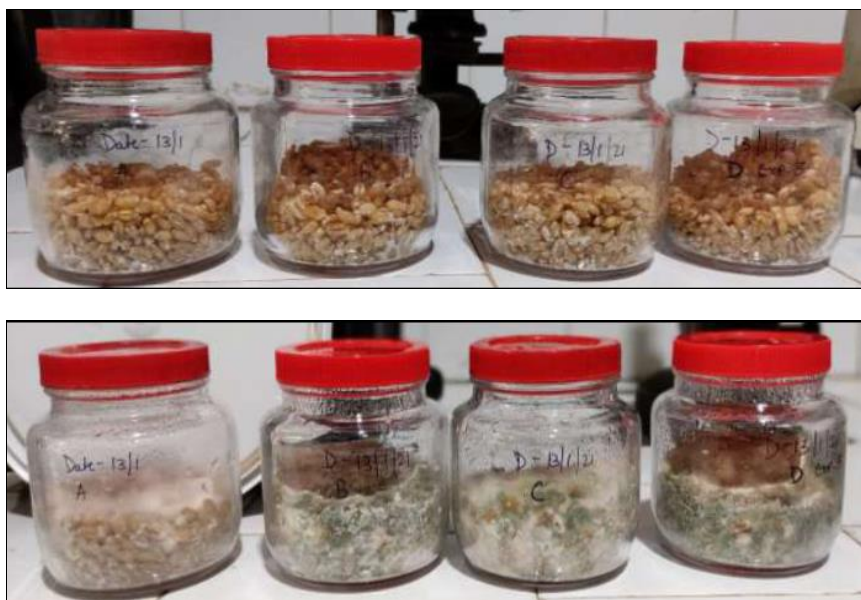


**Fig 2:** Preparation of inoculum for degradation of floral waste

For this the wheat grains were boiled partly or half cooked after soaking overnight so that the grains become slightly soft but do not burst. Excess water was drained out by placing the seeds on sieve and were allowed to dry for evaporation of surface water. The processed grain filled bottles were sterilised by autoclaving at 121 °C. After autoclaving, the bottles were taken out, cooled and inoculated with inoculums from the mother culture under sterile conditions. After inoculation, the bottles were

incubated (kept) at 37 °C for 2-3 weeks when the mycelium fully colonizes (covers) the wheat grains. These grains were used as inoculums for the degradation experiment conducted further.

### Set up of the experiment

Floral waste collected from temples were segregated to remove the waste like plastic and threads and then, were dried and processed for composting (Fig 3)



**Fig 3:** Segregation and preparation of floral waste for experiment set up

Three different types of floral waste were selected for experiment:

- Only the part of the flowers (petals) other than sepals and stem, both fresh and dry floral waste.
- Fresh flower floral waste
- Fresh floral waste collected dried in shade and powdered/ pulverized

The experiment was conducted by mixing the different ratios of soil, compost and floral waste (Fig 4). All the three materials were autoclaved in the polypropylene bags. The different ratios are:

- Set-1: 50% soil+33% compost+ 16% floral waste
- Set-2: 50% soil+25% compost+ 25% floral waste
- Set-3: 50% soil+16% floral waste+33% compost
- Set-4: 50% soil+50% floral waste

Inoculums was added to the different set ups. All the sets have 3 replicates with the fungi inoculated in it and one separate control was maintained for the comparison. The whole process was carried out under aseptic condition. The bags are tied up with the help of rubber bands and kept in incubator at 25 °C.



**Fig 4:** Set up at day of inoculation. Sets have different ratios of soil, compost and floral waste: A-50% soil+33% compost+ 16% floral waste, B-50% soil+25% compost+ 25% floral waste, C-50% soil +16% floral waste +33% compost, D- 50% soil +50% floral waste

### Analysis of Organic Carbon (OC)

**OC is the key factor for soil fertility that releases nutrients that helps in plant growth and biological health of soil**

The floral waste gets degraded and recycled in the soil. The minerals are released in soil and helps in the plant growth. Estimate of OC is relatively an important aspect as the degradation of floral waste which contains highly complex structures is broken down to simple organic compounds. The compounds have relatively high number of carbon present in them. Thus, we can analyze the change in the organic carbon before and after incubation of sets.

The determination is carried out with the help of Walkley-Black chromic acid oxidation method.

The process includes the estimation of carbon in the sets after incubation and comparing it with the standard graph.

### Determination of germination index

Germination index is an important indicator for presence of low molecular substances like ammonia and organic acids generated after the decomposition by fungi. It is an essential factor for checking the efficiency of the compost.

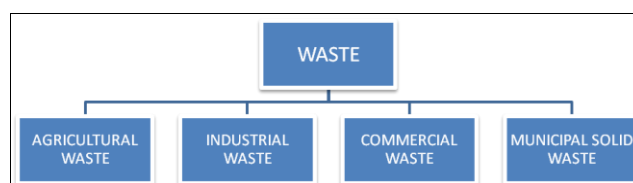
The index was determined by using pigeon pea (*Cajanus cajan*) and the compost made up from floral waste after one week. Ten seeds of pigeon pea are taken and sowed in the small cups having the compost of different sets and five

seeds for the control. Results were evaluated by counting the number of seeds germinated, at which day the radical emerges out and the length of shoot.

### Result and Discussion

Waste can be defined as “the substances which are discarded or eliminated after utilizing them for obtaining new products or their consumption”. Waste generation is a fundamental component of an ecosystem. Each and every element of ecosystem contributes to this component in one or other way. With the amelioration in human actions for better lifestyle, there is a quantum leap in waste generation. The waste not only got incremented by volume, but also by the level of complexity. This slows down the rate of decomposition by means of natural processes. Thus, waste management holds the single post for governing the better sustainability of nature’s home and human habitat.

Depending on the sources of their origin, waste can be of several types. Ramachandra (2011) <sup>[23]</sup> had classified them as:



Municipal Solid Waste (MSW) is defined as the waste generated by the everyday domestic activities by the citizens, in temples, streets in municipal notified area. Though, there are numerous ways of emergence of waste, the municipalities and Urban Local Bodies (ULB) plays a traditional role in collecting and managing the waste across the territory.

With the rapid elevation of waste generation, Management is the key to all the problems. Waste management is the essential practice to clear the discarded materials in easy and scientific way. The management becomes an important part in order to prevent pollution of various elements of planet-renewable and nonrenewable resources, to make the complete use of waste by composting, recycling, energy production. Various concepts have been come forward for the waste management and also for generation. The concept of 3 R's- Reduce, Reuse, Recycle gave the understanding of minimizing the use of non-degradable materials and use the materials which are friendly to the nature. Another concept is The Waste Management Hierarchy which underlines the set of priorities of waste that is generated and the preferences required for a better environment.

Municipal Solid Waste (Management & Handling Rules, 2000) formulated the whole process for managing domestic waste as collection, segregation, storage, transportation, processing and disposal (State and Environment Report, Gujarat, 2012) <sup>[16]</sup>.

The first step towards the management is the collection of domestic waste door-to-door. State government and ULB plays important role in the whole process, they plan and execute the mechanism of collection and processing of waste. The ULBs or the contractual workers are appointed serve the purpose of collection of waste from doors. But the foremost responsibility is of the natives to segregate the waste as wet and dry so that the collectors don't need to put more energy in separating them. There are total 84, 475 wards in the overall country, out of which 81, 135 wards have the facility of 100% door to door waste collection (Reply to unstarred question no. 1998, answered in Rajyasabha on 11 March, 2020 regarding "Waste management in Urban areas" by Minister of State (Independent Charge) of Ministry of housing and urban affairs, Shri Hardeep Singh Puri).

From the reports submitted after the Survey of ULBs by PAS, 2008-09, it came to light that 8566.54 tons of solid waste is generated from all urban areas of Gujarat (State of Environment Report Gujarat, 2012) <sup>[16]</sup>. On the report presentation done at Rajyasabha on 27 June, 2019 regarding the 'Disposal of Municipal Waste', The Ministry of Housing and Urban Affairs mentioned the waste generation by states and major cities of state. The report signifies the fair amount of waste production in Gujarat. The report also listed out the amount by various cities such as Ahmedabad-1079 MT/D, Vadodara- 365 MT/D, Gandhinagar- 32 MT/D and Dahod-15 MT/D. According to CPCB 2012 <sup>[17]</sup>, Maharashtra stands first with 192.04 MT/D while, Gujarat produces 8566.54 tons per day. As according to survey and report of CPCB in 2012 <sup>[17]</sup>, it came to note that MSW generation was 7379 TPD and 6744 TPD was collected in the year 2010-11 in Gujarat state.

In the study conducted by Mitu Mewada *et al* (2020) <sup>[6]</sup>, Vadodara city contributes actively in waste generation. The

study well explained the structure of waste handling right out from the home to the landfills. The collection and the segregation of the waste materials are done first in the temporary landfills located at the major zones of the city. The main landfill area where the waste gets dumped is located at Jambuva and the waste had reached around 20 ft in height.

Organic waste generally includes the household discards, street waste, temples wastes, etc. The part of these community wastes comes from the religious places such as community center, temples, dargahs, gurudwara etc which needs attention for proper disposal. Flowers are the symbol of devotion and reverence (Mahindrakar A, 2017). Flowers come from various sources such as marriages, gardens, temples, dargahs and various other cultural as well as religious practices. In India, religion is the intrinsic part of life. The different things offered by devotees are piled up and then discarded to water bodies (Singh and Singh, 2007). Amount of floral waste varies from city to city. Being a country full of festivals and occasions celebrated all-round the year, India generates lakh tones of waste every year. In the cities having many pilgrimage spots produces high amount of waste. It increases more during the festival seasons. Banaras, one of the holiest city of India generates 3.5-4 tons of waste by the temples every day. But it is left behind with no system of disposal in the city (Mishra, 2013) <sup>[8]</sup>. Approximately, 1450 tons of floral waste are generated every day and cause environment pollution (Ravishankar *et al* 2014) <sup>[11]</sup>. Mishra and Joshi (2002) <sup>[7]</sup> estimated that 1873.7 kg of organic waste was generated every day in Hardwar city. During important six occasions, 20,435 kg solid waste was generated in the year 1997.

Floral waste is an environmental issue affecting the water bodies the most. Ganga, an important river of country, originates from Himalayas and passes through many cities. Pollutants from the industries and Municipal waste are added to the water and make it unusable to humans. Along with this, the river receives huge amount of flowers and ashes on its bank. Looking into the impact of waste flowers to the environment, there is a demand of systematic and scientific utilization or disposal of the waste. Floral waste management becomes an important aspect in the modern era.

In India, population prefers to visit temples regularly and believed to offer flowers as part of their worship. This led to generation of temple waste which is preferred to drop down to rivers rather than mixing with municipal waste.

Mostly in all holy places' flowers are usually offered by devotees to their god's & also used for decorating the temples. There is a tradition in India to offer specific flower to specific god. Different types of flowers like; Rose, Hibiscus, Chrysanthemum, Jasmin, Marigold, Tulsi, Banana or Mango leaves etc. are been offered. Every city of India, daily these flowers offered by the devotees in temples are left unused and therefore become waste (Waghmode *et al.*, 2018) <sup>[19]</sup>. Temples are decorated with flowers of different kinds as well as flowers are offered to God & Goddess at the time of puja (Yadav *et al.*, 2018) <sup>[21]</sup>.

In the present study 16 temples which were widely visited by devotees making floral offerings were visited (Table 1) and survey was carried out. In Vadodara itself large amount of floral waste is generated. Diversity of flowers and leaves

being offered in the different temples. Majority of the public offers Chrysanthemum/marigold, rose, jasmine and mogra. Leaves are basically of Polyalthia, mango and Ocimum/tulsi.

During the interrogation with the pujaris, it came to highlight that the number of devotees and the floral offered to deity gets increased in festivals. The method for offering flowers varies from temple to temple and the disposal methods too. During the interrogation with the *pujaris*, it has been known that mostly the waste are dumped into the river bodies or vans of Vadodara Municipal Commission

(VMC) pick them and dump to the landfills, mixing it to other municipal solid waste. Devotees from local as well as other cities visit temple and offer flowers, fruits, coconut and sweets as part of their prayers. It is well observed that many temples avoid throwing the flowers and other items offered to deity in bin because of religious belief. These led to packing the waste in plastic bags and dispose it in the water bodies nearby. This cause water pollution and makes the resource inadequate for human consumption. Some are thrown nearby in open land which leads to land pollution, foul smell and a source of disease.

**Table 1:** Temples visited for survey in Vadodara and the florql type and waste generated per day

| Sr. No. | Name of temple                     | Location                            | Flowers offered                                                                | Quantity of total waste (kg/day) |
|---------|------------------------------------|-------------------------------------|--------------------------------------------------------------------------------|----------------------------------|
| 1.      | Gurudwara                          | Near airport                        | Marigold, Lily, Rose, Mogra                                                    | 0.3                              |
| 2.      | Ashtavinayak temple                | Panigate                            | Hibiscus, Rose, Marigold, Mogra, <i>Cynadon</i>                                | 5.0                              |
| 3.      | Swaminarayan Temple                | Karelibagh                          | Rose, Sunflower, Jasmine, <i>Ocimum sp.</i>                                    | 2.0                              |
| 4.      | Jalaram temple                     | Karelibagh                          | Rose, Lily, Mogra, leaves of Asopalav, Jasmine                                 | 5.2                              |
| 5.      | Panchmukhi Hanuman                 | Near Kalaghoda                      | Rose, Calotropis, Mogra, Mango leaves                                          | 6.3                              |
| 6.      | Dutt mandir(Kirti mandir)          | Near Kalaghoda                      | Rose, Marigold, Lily, Mogra, Rose                                              | 3.6                              |
| 7.      | Ambe temple                        | Mandvi                              | Rose, Mogra, Marigold, Karanj                                                  | 7                                |
| 8.      | Kashivishwanath                    | Near Manjalpur                      | Lily, Mogra, Rose, Marigold, Jasmine, Calotropis                               | 5.0                              |
| 9.      | Iskcon Temple                      | Diwalipura road                     | Lotus, Rose, Lily, Mogra, Marigold, Tulsi, Jasmine, Safflower, <i>Plumeria</i> | 8.1                              |
| 10.     | Haribhakti Raneshwar Temple        | Diwalipura                          | Rose, <i>Chrysanthamum</i> , Lotus, Lily, <i>Ocimum sp.</i> , Mogra            | 2.5                              |
| 11.     | Hanuman temple                     | Vrundavan crossroads                | <i>Calotropis</i> , sunflower                                                  | 5.3                              |
| 12.     | Sai temple                         | Bapod village                       | Rose, Marigold, Lily, Mogra, <i>Cascabela theretia</i> (Karen)                 | 1.9                              |
| 13.     | Sarveshwar Mahadev Mandir          | Jalram Nagar, Madhavpura, Vadodara, | Clitoria, Hibiscus, Marigold, Rosel Datura, Bael Leaves, Chrysanthemum         | 2.5                              |
| 14.     | Shree Ayyappa Temple               | New Sama, Chhani Road               | Tulsi, Jasmine, Rose, Marigold                                                 | 6                                |
| 15.     | Shree Sankat Mochan Hanuman Mandir | Kendranagar Vadodara                | Marigold, Calotropis, Rose, Jasmine, Chrysanthemum                             | 3.5                              |
| 16.     | Shree Lakshminarayan Mandir        | Manjalpur                           | Lotus, Tulsi, Lily, Rose, Marigold                                             | 3                                |

The materials offered to god are considered holy by the people and they believe not to throw them along with the other waste like sewage, sanitary or industrial. This makes the authorities of temples to dump the waste to the nearby water bodies. No such systematic way of disposal has been noted except in one of the gurudwara in the Karelibagh area of the city. The number of flowers offered is minimal and they have their own method of preparing compost.

During the survey it was also noted that different temples have their own significant flowers offered to god. Flowers like Hibiscus, Rose, Marigold, Mogra, *Cynadon*, Lotus, Lily, Tulsi, Jasmine, Safflower, *Plumeria* etc.

Along with flower waste, other materials such as plastic bags, papers, coconut shells, etc are produced. Though the amount of non-degradable things is less as compared to degradable flowers, but the proportion can't be neglected.

Instead of making plans on reduction of waste generation, one must focus on utilizing the waste in scientific way.

With the awareness in the temple authorities and local people, many temples become the leading example of proper disposal of waste. Kashi Vishwanath temple, a well-known pilgrimage in India, attracts maximum number of devotees throughout the year, but it increases during the month of Shravan. The trust has adapted a well-organized system of disposal for kilograms of flowers offered to god. They convert the floral waste to manure (Mishra, 2013) [8].

Composting is one of the best ways of utilizing the floral

waste around the source. Floral waste degradation is rather slower than the other kitchen waste degradation (Jadhav, 2013) [4]. Composting is defined as the breakdown of complex organic compounds present in the waste into small fragments. The process can be enhanced by addition of microorganisms. Flower waste contains good amount of organic composition and this can turn into high value compost.

Gaurav and Pathade (2011) [2] mixed the effluent released for the biogas digester and temple waste along with the cattle dung and allow decomposing for 30 days at the temperature of 30 C. The resultant was then used for pot culture with five flowering plants. The growth parameters were noted and the comparison was done with the control sets.

Modern technologies make best use of efficient microorganisms with noteworthy cellulolytic capabilities for reducing the normal duration of traditional processes. (Moses Kolet, 2013) [9].

Sailaja *et al* (2013) collected flowers from temples to convert it to vermicompost. They examined the nutrient status of compost prepared and concluded that the growth rate of plants are high as compared to the control. Vermicompost contains plant hormones like Auxin and Gibberellins which assume to be a good factor for plant growth and resistant to plant pathogens.

Silvuai and Aneeshia (2014) [15] attempted to make the

valuable compost from the waste generated from temples. They used *Ganoderma incidunt*, *Pleurotus sapidus*, and *Pleurotus flabellatus*. They found that the *Pleurotus* species was effective in decomposition of waste as compared to other two.

Tiwari (2014) <sup>[18]</sup> conducted an experiment that converts the floral waste into suitable compost. Vermicomposting was used as a technology to utilize the floral waste completely. The waste was collected from ten temples of Jaipur, segregated and kept in earthen pots in different proportions. Parameters like pH, temperature, organic carbon, available phosphorus and moisture content were checked for the vermicompost prepared. It was finally concluded that floral waste are one of the efficient substrate for vermicomposting. Makhania and Upadhyay (2015) <sup>[5]</sup> experimented on degradation aspects of floral waste from the Surat city. The observations were noted up to 50 days and they monitor changes in physio-chemical parameters. They found that maximum temperature is noted at 4<sup>th</sup> day of composting and proves that the composting is effective zero waste strategy for treating floral waste.

Aakanksha Mahindrakar (2018) <sup>[1]</sup> studied the effect of fertilizer made up of floral waste vermicompost on growth parameters of Tomato (*Solanum lycopersicum* L.)

Various techniques such as rotary drum are used in many experiments to determine physiochemical and biological changes during composting of flower waste (Sharma and Yadav, 2018) <sup>[14, 21]</sup>.

Fungi are the important driving force of composting. Filamentous fungi mostly have the metabolic capacity to degrade cellulose containing materials. Fungi used in the composting can reveal many advantages as it already has the presence of enzymes for degradation and fungi by its own promotes the growth of plants. Enzymes like xylanase, chitinase and beta-glucanase are linked to the biocontrol role while cellulase is associated with phytopathogenic effect.

The division of fungi- Ascomycetes includes the well-

known filamentous fungi like *Trichoderma*, *Aspergillus*, *Neurospora* and *Saccharomyces*. This kind mainly focuses on degrading biomass showing the presence of cellulose and hemicellulose. The complex structure of cellulose is believed to be well broken by the fungal species of genera- *Trichoderma* and *Aspergillus*.

*Trichoderma* is the fungi genus belonging to Ascomycetes, present in soil and are known to be the most culturable fungi. *Trichoderma* species are known to secrete large number of extracellular enzymes. These genus are able to degrade cellulose, hemicelluloses and lignin by hydrolytic and oxidative enzymes secreted which eventually degrade plant materials. The fungi plays important role via the mechanisms like mycoparasitism, competition and biocontrol agent.

Studies revealed that the hyphae of *Trichoderma* taken as biocontrol agent penetrated into infected epidermis and cortex of roots and destroyed the hyphae of pathogen. Because of the great potential identified in *Trichoderma* this fungal species was used for the degradation of floral waste in the present study.

In the present study, an experiment conducted to turn an efficient and scientific way for creating compost out of the temple waste. The floral waste, compost and soil were added along with fungi in the bags and kept in incubator for one week.

After one week, fungi can be morphologically seen clearly to be grown well as white strands (fig.5-A and B). This indicates the substrates are well for fungi and optimum conditions were prevailing for their growth. The fungi show whitish fibrous appearance and the floral waste turns black indicating the degradation process.

The weights of the bags were checked with the help of weighing balance in order to get the weight of mycelium grown in a week. For the mycelia weight, the weight before and after drying the compost were noted. Weight of mycelia indicates the growth of fungi to do the degradation process.



**Fig 5:** Set up after one week of inoculation shows clear growth of fungi

Organic carbon is an important aspect of this study. This is one of the parameter to determine the activity of fungi. The substantial breakdown of highly complex structures to

simple carbon form indicates the rise in carbon and it is analyzed through spectrophotometer

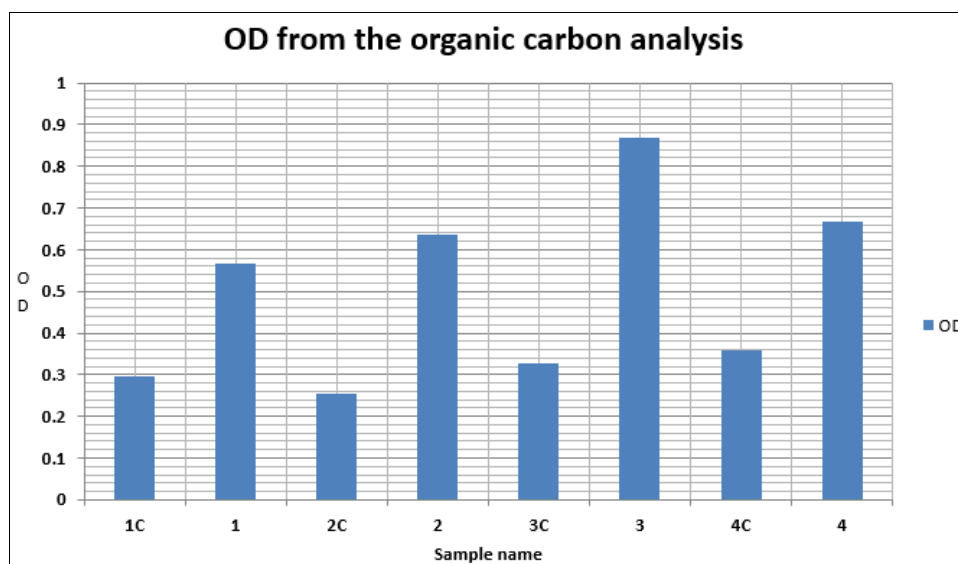


**Fig 6:** Organic carbon analysis of the different set up of experiments detected at OD 660 nm

After one week, the carbon was analyzed in each of the samples. It came as result that the set which has the fungi inoculated in it, shows high OD as compared to their respective control. The reason maybe the fungi have high potential of degradation and releasing carbon around which gets analyzed by our estimation method. All the sets show good and high OD. The Optical Density so obtained don't fit into the standard curve as it goes beyond the limits, but from the values obtained in spectrophotometer as shown in figure 11, it can be said that the amount of carbon increases significantly.

The third set which has 50% soil+ 16% compost+33% floral waste with fungi shows the highest OD. It significantly proves to be the best for having the highest source for carbon.

Germination is another aspect targeted in the present study.

After one week, the mixture from the polypropylene bags is transferred to small pots. The seeds of pigeon pea are sown in the pots and allowed to grow. The observations are noted down every day about the growth of seeds in terms of length of shoots and day at which plumule came out.

Day-3 was the phase where the plumule from majority of pots except the control was observable. In the Set-1, 6 out of 10 seeds emerges out, in Set-2, 3 out of 10 seeds came out in form of plumule. Set-3 had 3 seeds emerging out and Set-4 has 2 seeds out of 10.

As the days passed, there is remarkable increase in the germination of seeds. On day-4, first leaves came out from the plumule. This was considered as successful establishment of plants in pot.

The graphs show the comparison of days and number of seeds germinated.

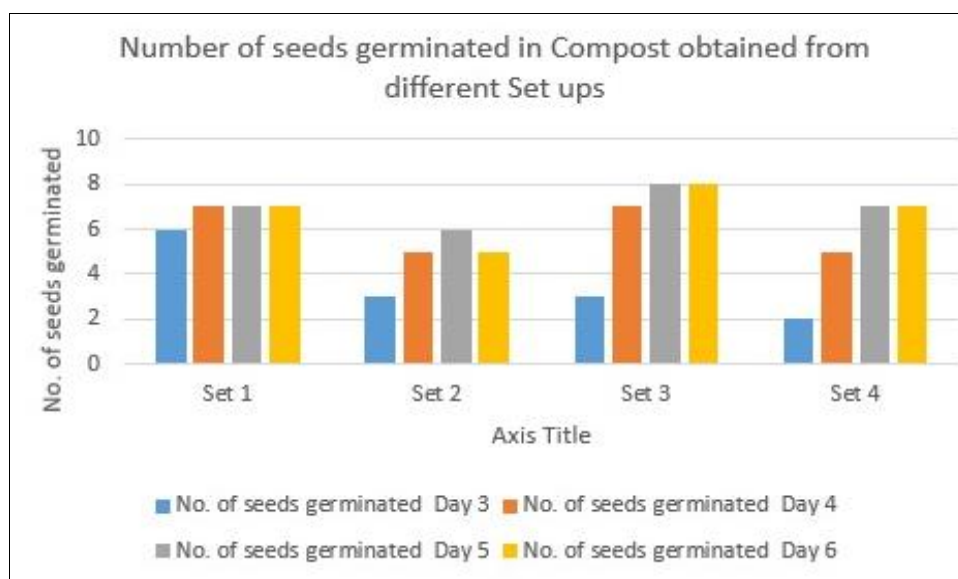


**Fig 7:** Graph showing number of seeds germinated in Compost obtained from experimental Set up-1, 2 3 and 4 during the stipulated time

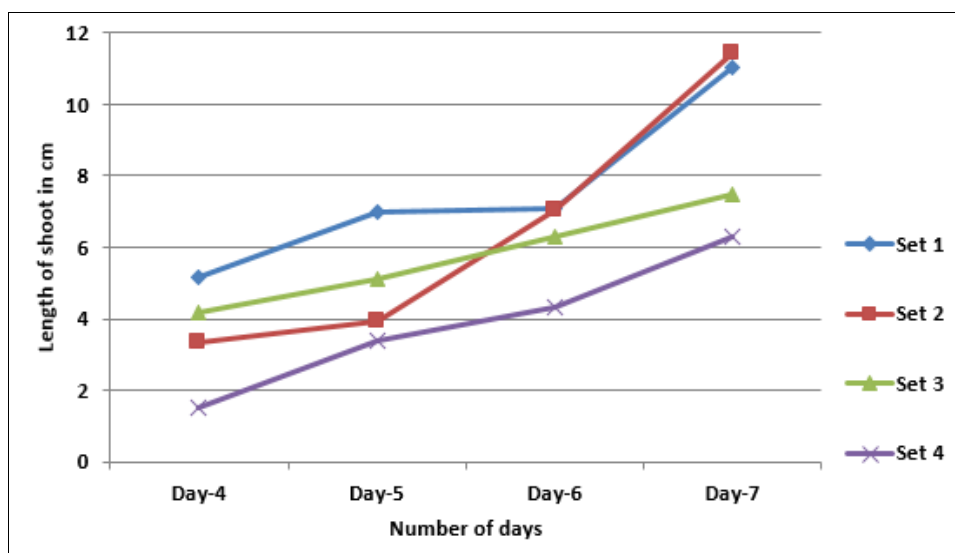


**Fig 8:** Variations in the shoot length of seeds germinated and grown under the different set ups.

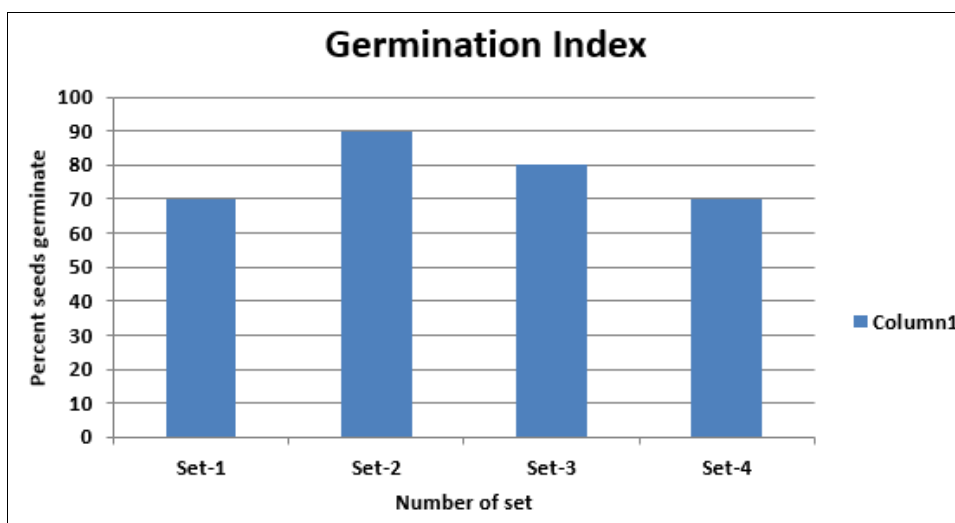


**Fig 9:** Germination indexes of sets in pots calculated by GI formula

According to the formula, Seed germination index is given by

$$\text{Seed Germination Index (\%)} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

The index was calculated for each sample and is represented in the Fig 9.

The Germination Index is an indicator for properly establishing plant and it also signifies the efficiency of substrate for the plants to grow.

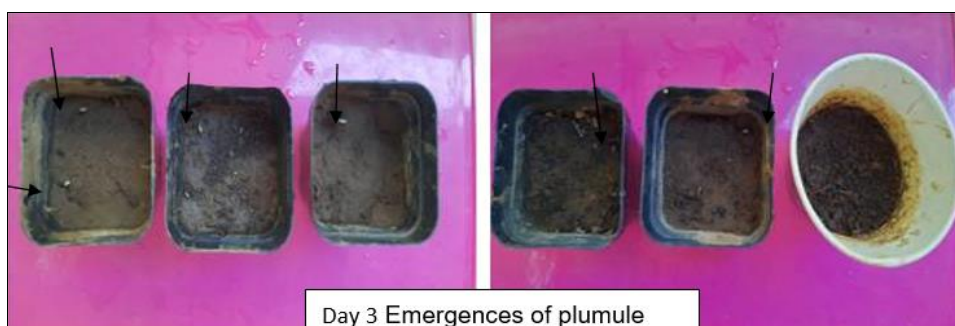




**Fig 10:** Emergence of different parts of shoot during the different days of growth

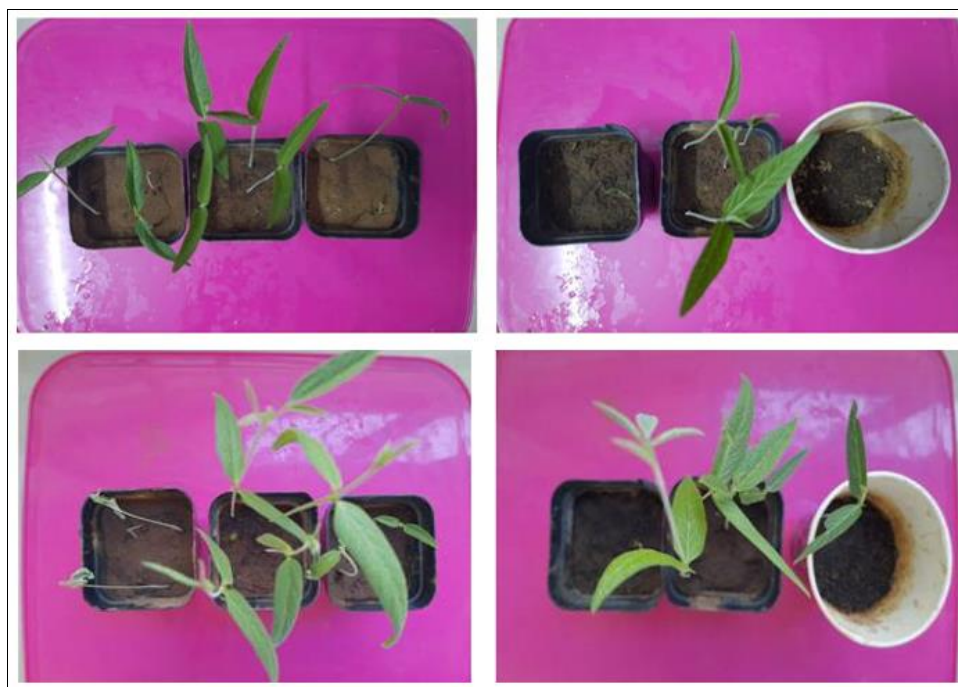


**Fig 11:** Leaves increasing in number and the length.

Set up 3 had organic carbon the maximum, however all the other parameters evaluated showed the Set-2 ie., 50% soil +25% compost+ 25% floral waste to be the best for the growth of the plants.

### Conclusion

The scenario of waste generation is tremendous in this generation. The waste is a problem prevailing in global as well as local level. But due to awareness in people about the environment related issues, certain small initiatives are taken up for bioremediation of the waste. Various attempts have been carried out for sustainability of ecological atmosphere and some got the fruitful results too.

Floral waste as part of Municipal Solid Waste creates a chaos by the issue of their proper disposal. The mindset of 'best out of waste' can probably give a way for managing this waste. The present study dealt with the effective management of floral waste with the help of fungi. *Trichoderma* proved to be one of the best elements for degradation of flowers. Fungi are known to be the havoc in plants by inducing plant diseases, but some fungi are known to be the growth inducers in plants. *Trichoderma* is one of the fungi that have growth inducing effects too. The results demonstrated that inoculation of fungi with waste turns the waste to degrade rapidly, achieving faster compost preparation. The OC level also changes significantly

indicating the degradation and the germination rate also prove to be effective. Today, in the era of organic food demand, farmers and local business are constantly in requirement of natural fertilizers rather than chemicals. Thus, the compost so prepared in the study can prove to be the effective one for the organic culture.

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