Study Area

India is known as a holy land worldwide. India is the country where people have immense faith in God and his powers. The country boasts of a rich cultural heritage, which is truly reflected in its well-preserved temples that reflect superb architectural skills and hold deep religious significance. There is hardly any city, any town or any village in the country that does not have temples.

The study involved the following steps-

Selection of Temples

Jaipur is known as the “city of temples”. Jaipur has been called the “Chhoti Kashi” due to its religious significance. The city houses several temples which are located in almost all parts of the city but concentrated in the old city. The cultural roots of Jaipur are reflected in these temples. According to Devsthan Vibhag Report, 467 temples trust were registered till 2013. There are 30 temples in the city which come under Devsthan Vibhag. In the present study 8 of the total temples selected, are registered under this department.

Since the study deals with flower waste management of temples, therefore garlands and flowers were collected from temples to carry out vermicomposting and handmade paper making. The following temples were selected on the basis of their popularity:

1. Jharkhand Mahadev
2. Moti Dungri
3. Khole ke Hanumanji
4. Kale Hanumanji
5. Surya temple
6. Govind Dev Ji
7. Tadkeshwar temple
8. Hanuman Vatika
9. Shila Mata temple
10. Chandpole wale Hanumanji
1. **Jharkhand Mahadev** is a Lord Shiva temple famous for its *shivling* which is known to have been self manifested. It is located at Queen’s road, Vaishali Nagar. There is a legend that for salvation the pilgrim who visits the four *dhaams* must also visit this temple else the pilgrimage is not deemed completed. It is for the deep faith and devotion of the devotees that this temple has become a place of pilgrimage.

![Figure 1: Jharkhand Mahadev](image1)

2. **Moti Dungri Ganesh Ji** is dedicated to Lord Ganesha. It sits on a small hill, centrally located at Moti Dungri Road, Tilak Nagar. The hill is occupied by a palace and the temple. The term *Moti Dungri* means Hill of Pearls or Pearl Hill. It is one of the most famous temples of the city and has regular inflow of devotees.

![Figure 2: Moti Dungri Ganesh ji](image2)
3. **Khole ke Hanumanji** is a temple of almighty Lord Hanuman. It is situated at Laxman Dungri, Delhi bypass, Jaipur. The temple is entitled as famous and is one of the ancient temples of Rajasthan.

![Figure 3: Khole K Hanuman ji](image)

4. **Kale Hanumanji** temple is famous for its idol of Lord Hanuman which is black in colour. It is located at Chandi ki Taksal, Janta Market, Amer road. Generally, any temple of Lord Hanuman has a red or orange coloured idol of the Lord, but Kale Hanumanji is famous for its unique coloured idol.

![Figure 4: Kale Hanuman ji](image)
5. **Galtaji** is a holy pilgrimage of India dedicated to the Sun God. It is located 10 kms away from Jaipur near Sisodia Garden. The vast complex of Galtaji has several temples in it. It is famous for its natural water springs.

![Figure 5: Galtaji](image)

6. **Govind Devji** is dedicated to Lord Krishna popularly known as Govind Dev Ji. This temple is situated in the City Palace complex, between the Chandra Mahal and Badal Mahal at Jaleb chowk. It represents the royal past of Jaipur.

![Figure 6: Govind Devji](image)
7. *Tadkeshwar Mahadev* is the temple of Lord Shiva. This temple is located behind the City Palace Complex at Chaura Rasta. It is one of the most worshipped places of Jaipur.

![Figure 7: Tadkeshwar Mahadev](image)

8. *Hanuman Vatika* temple is the famous temple of Lord Hanuman. It is situated at Hanuman Nagar, Vaishali Nagar. This temple also houses the idols of Goddess Durga and a Shivling.

![Figure 8: Hanuman Vatika](image)
9. **Shila Mata Temple** also known as the Kali Temple. This temple is located in the breathtakingly beautiful Amber Palace complex. It is an intriguingly astounding temple of the 16th century dedicated to the Goddess Kali.

![Figure 9: Shila Mata](image)

10. **Chandpole waale Hanumanji** is a famous temple of Lord Hanuman, situated in heart of the city “Chandpole”. The temple is crowded day long with people who believe that whatever they wish comes true here.

![Figure 10: Chandpole Waale Hanumanji](image)
Visit to the Selected Temples

Regular visits were made to the selected temples for a month for collecting the primary data. Since each temple has its special days depending on the deities; days of visit were selected accordingly.

Table 2: Visit Schedule

<table>
<thead>
<tr>
<th>Name of the Temple</th>
<th>Days/Occasion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jharkhand Temple</td>
<td>Mondays and <em>Shrawan Maas</em></td>
</tr>
<tr>
<td>Moti Dungri Ganesh Temple</td>
<td>Wednesdays and <em>Ganesh Chaturthi</em></td>
</tr>
<tr>
<td>Khole ke Hanumanji</td>
<td>Tuesdays and Saturdays</td>
</tr>
<tr>
<td>Kale Hanumanji</td>
<td>Tuesdays and Saturdays</td>
</tr>
<tr>
<td>Seeta mata Temple</td>
<td>After Diwali during <em>Kaarik Maas</em></td>
</tr>
<tr>
<td>Govind Dev ji</td>
<td>Sunday and <em>Janmashtami</em></td>
</tr>
<tr>
<td>Tadkeshwar Temple</td>
<td>Mondays and <em>Shrawan Maas</em></td>
</tr>
<tr>
<td>Hanuman Vatika Temple</td>
<td>Tuesdays and Saturdays</td>
</tr>
<tr>
<td>Shila Mata Temple</td>
<td>Saturdays and <em>Navaratri</em></td>
</tr>
<tr>
<td>Chandpole waale Hanuman ji</td>
<td>Tuesdays and Saturdays</td>
</tr>
</tbody>
</table>

- **Collection of data**

A Questionnaire was designed to interview the temple authorities and *Mahantas* regarding no. of visitors, the quantity of the waste generated daily/ during festive season and the method of disposal used in these temples.

- **Collection of waste**

Floral Waste was collected every alternate day for 15 days from one of the selected temples as the composition of waste was found to be same in almost all the temples (Figure 11).
Material and Methods

Figure 11: Collection of waste

➤ Characterization of waste

Waste collected from temples was a mixture of biodegradable and non-biodegradable waste. So firstly this waste was characterized as biodegradable and non-biodegradable. The biodegradable part consists of items such as flower, cotton, matchsticks, incense sticks, *kumkum*, food items, coconut etc. whereas polythene, baskets, textiles form the non-biodegradable part of waste (Figure 12).

Figure 12: Waste outside temple (before segregation)
Segregation of Biodegradable waste (flowers)

Non-biodegradable part was removed by hand sorting. From the biodegradable waste, garlands and flowers were segregated; from this the different flowers like Marigold (genda), Rose and Mogra were further separated. Garlands were dismantled. Marigold was chosen for vermicomposting because it was present in the highest amount (80% Marigold, 10% Roses and 10% other flowers). Rose along with Marigold was segregated for Handmade Paper Making and mottling.

Marigold:
Systematic Classification of Marigold:

Kingdom - Plantae
Division - Magnoliophyta
Class - Magnoliopsida
Order - Asterales
Family - Asteraceae
Genus - Calendula
Scientific Name - Calendula officinalis

*Calendula officinalis* commonly known as Marigold, is an annual plant. It comes in different colours, most commonly in yellow and orange. Most of the marigolds have strong and acrid odour. Marigold (*Calendula*) is an immensely efficient herb for the treatment of skin problems. Marigold has high aesthetic value and is popularly used in garlands and to decorate religious statues and buildings and also during weddings and other ceremonies. It is also used as offerings in temples etc. Pigments in Marigolds are sometimes extracted and used as a food colouring agents.

Rose:
Systematic Classification of Rose:

Kingdom - Plantae
Order - Rosales
Family - Rosaceae
Genus - Rosa
Scientific Name - Rosa indica
Rosa indica is a woody perennial plant. Roses occur in a variety of colours; red, pink, yellow and orange being the most common. Roses are best known as ornamental plants grown for their flowers in gardens and farms. They have a characteristic sweet aroma. Hence they are used for making perfumes, essence and rose water. Apart from this, they have functional uses as well in the form of landscape plants and for hedging. They also have some medicinal uses.

A. Vermicomposting

The segregated floral waste was air dried by spreading over paper sheets (27×21.5 cms) for 48 hours (Figure 13). The air dried samples were then subjected to pre-composting for 10 days to make them suitable for the process (Figure 14). Pre-composting is a practice of processing and treating raw waste before vermicomposting. The waste materials, in the pre-composting process are decomposed aerobically by active role of bacteria (Figure 15). The pre-composting prior to vermicomposting because of its thermophilic nature helps in mass reduction and pathogen reduction (Nair et al., 2006).
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Figure 14: Pre-composting of Waste

Figure 15: Waste after pre-composting
Experimental Design

The experiments were conducted in earthen pots (9 pots) of diameter of 35 cms and height of 26.5 cms. Pots were first washed and dipped in water overnight. In each pot a measured amount of the substrate (floral waste), mixed with cow dung was taken in different proportions depending on the ratios viz., 50:50, 60:40, 70:30, 80:20 and 90:10 for vermicomposting and composting (Table 3, Figure 16). The Cow dung was collected from a nearby Gaushala. It was used as an inoculant in the vermicomposting process; it enhances the quality of feeding resource attracting the earthworms and accelerates the breakdown of wastes (Suthar and Singh, 2008). It was left for a day to remove excess heat. In the present study, *Eisenia foetida*, commonly known as red worm was used (Figure 17). It was procured from Rajasthan Gosewa Sangh, Tonk Road, Durgapura, Jaipur. It is omnipresent with a world-wide distribution. It has good temperature tolerance and can live in organic wastes with different moisture contents. The temperature tolerance for *E. foetida* is between 0°C to 35°C, and optimum temperature is 25°C. It can survive in moisture ranges between 50-90% (Sims and Gerard, 1985) but grows more rapidly between 80-90% (Edwards, 1988). It is rarely found in soil and is used for vermicomposting. It does not make burrow into soil, and is found in habitats where other worms will have a very difficult time surviving, therefore lessening the competition for food and space for them. 200 grams of earthworms were inoculated in each pot after 10 days of pre-decomposition.

### Table 3: Experimental Design for vermicomposting

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experimental Design</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Group 1- 50:50</td>
<td>Triplicates (500 grams waste+ 500 grams cowdung+200 grams earthworms) +control (without worms)</td>
</tr>
<tr>
<td>2.</td>
<td>Group 2- 60:40</td>
<td>Triplicates (600 grams waste+400 grams cowdung +200 grams earthworms)+control (without worms)</td>
</tr>
<tr>
<td>3.</td>
<td>Group 3- 70:30</td>
<td>Triplicates (700 grams waste+300 grams cowdung + 200 grams earthworms)+control (without worms)</td>
</tr>
<tr>
<td>4.</td>
<td>Group 4- 80:20</td>
<td>Triplicates (800 grams waste+200 grams cowdung +200 grams earthworms)+control (without worms)</td>
</tr>
<tr>
<td>5.</td>
<td>Group 5- 90:10</td>
<td>Triplicates (900 grams waste+100 grams cowdung +200 grams earthworms)+control (without worms)</td>
</tr>
</tbody>
</table>
Material and Methods

Figure 16: Measured amount of waste, cow-dung and earthworms was used

Figure 17: Earthworms (*Eisenia foetida*) used as culture for decomposition
All the pots were covered on the top by a jute cloth and a wire mesh to protect the earthworms from the predators; centipedes, moles and shrews and to prevent the moisture loss. Small holes were drilled at the bottom of each pot for air circulation and easy drainage. The process of vermicomposting and composting was carried out for a period of 50 days. The temperature and moisture content were maintained by sprinkling adequate quantity of water every day and upside down mixing of waste was done once daily. The pots were kept in dark humid place in the backyard of the University and temperature of 28°C-32°C was maintained. All the pots were monitored daily (Figure 18).

After the feed material got converted into loose, granular mounds due to feeding and defeacation of the worms, the entire material was collected from each replicate pot. The cast was passed through 3 mm sieve, the earthworms were removed manually (Figure 19). The cast was air dried by spreading in large trays. After sufficient moisture was lost, samples were sealed, labelled for further analysis (Figure 20). The bioconversion ratio of flower waste into vermicompost for all the groups was also calculated.
Figure 19: Sieving of the vermicompost prepared

Figure 20: Labelled and sealed vermicompost samples
Material and Methods

- Experimental Protocol

- Physico-Chemical Analysis

The following parameters were analyzed:

- Moisture Content (MC)
- Temperature
- pH
- Electrical conductivity (EC)
- Organic Carbon (OC)
- Total Nitrogen (N)
- Available Phosphorus (P)
- Exchangeable Potassium (K)
- Calcium (Ca)
- Magnesium (Mg)

Table 4: Methods used for different parameters

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Parameters</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Moisture Content (MC)</td>
<td>Jackson, 1973</td>
</tr>
<tr>
<td>2.</td>
<td>Temperature</td>
<td>Jackson, 1973</td>
</tr>
<tr>
<td>3.</td>
<td>pH</td>
<td>Jackson, 1973</td>
</tr>
<tr>
<td>4.</td>
<td>Electrical conductivity (EC)</td>
<td>Jackson, 1973</td>
</tr>
<tr>
<td>5.</td>
<td>Organic Carbon (OC)</td>
<td>Walkley and Black, 1934</td>
</tr>
<tr>
<td>7.</td>
<td>Available Phosphorus (P)</td>
<td>Bhargava and Raghupathi, 1993</td>
</tr>
<tr>
<td>8.</td>
<td>Exchangeable Potassium (K)</td>
<td>Bhargava and Raghupathi, 1993</td>
</tr>
<tr>
<td>9.</td>
<td>Calcium (Ca)</td>
<td>Cheng and Bray, 1951</td>
</tr>
<tr>
<td>10.</td>
<td>Magnesium (Mg)</td>
<td>Cheng and Bray, 1951</td>
</tr>
</tbody>
</table>

All determinations were carried out in triplicate.

Moisture Content (Jackson, 1973)

Moisture is essential for the metabolic processes of microbes. The MC content of composting materials should be maintained within a range of 40% to 65%. The composting process becomes inhibited when the MC is below 40%. MC
generally decreases as composting proceeds and water addition may also be needed to maintain the required moisture level. The oven dry method was used which determines total water.

Procedure-

Moisture content was measured gravimetrically. 5 grams sample were taken, then kept in incubator for 24 hrs at 70°C and then weight of the dry sample was taken and moisture content was estimated in all the groups throughout the vermicomposting process.

Formula Used-

\[
\text{% Moisture} = \frac{100(B-C)}{B-A}
\]

Where,

- A= weight of empty petri dish
- B= weight of petri dish with material before drying
- C= weight of petri dish with material after drying

Temperature (Jackson, 1973)

Temperature was noted every 10\textsuperscript{th} day throughout the process with LCD digital thermometer at the depth of 10 cms from three different sites and their mean value was taken in centigrade.

pH (Jackson, 1973)

The pH can be defined as negative logarithm of hydrogen ion activity and expresses the degree of acidity or alkalinity.

Principle-

It is a measure of H\textsuperscript{+} ion and OH\textsuperscript{-} ion activity of the sample and is an indicator of chemical processes that occur in sample. Since change in pH affects the growth of microbes present in sample, hence the estimation of pH is an important parameter.
Material and Methods

Procedure-

The pH of samples was recorded by a digital pH meter Elico-111E throughout the process. 1:2 sample water extract was prepared in 100 ml beaker. The suspension was shaken at regular intervals for half an hour. pH meter was set at room temperature and calibrated by immersing the electrodes in different buffer solutions of pH 4.0 and 7.0. Electrodes were dipped into the solution and pH was noted.

**Electrical Conductivity (Jackson, 1973)**

Electrical Conductivity (EC) is a reverse of resistance and can be related directly to soluble salts concentration in the sample at a particular temperature.

Principle-

The EC of the sample rises according to the content of soluble salts (as ions are the carriers of electric charge).

Procedure-

EC was measured by conductivity meter Century- CC 601. 1:2 sample water extract was prepared in 100 ml beaker. The suspension was shaken at regular intervals for half an hour. Conductivity meter was adjusted at 25°C. The reading was taken by dipping the conductivity cell into the solution. It was calculated throughout the process.

**Organic carbon (Walkley and Black, 1934)**

Organic matter is complex in nature because of which numerous difficulties beset its accurate determination. Organic matter is far more generally calculated from a determination of organic carbon. The proportion of carbon in organic matter varies widely. Since organic carbon can be determined directly, and with considerable accuracy, it is preferable to report it as such, rather than a value for organic matter derived from it.

Principle-

Organic carbon is oxidized to CO₂ by heat of dilution obtained when a known amount of sample is treated with excess of standard K₂Cr₂O₇ in the presence of concentrated H₂SO₄. The excess of K₂Cr₂O₇ not reduced by the organic matter is
Material and Methods

back titrated with standard ferrous ammonium sulphate in the presence of phosphoric acid or sodium fluoride using diphenyl indicator. At the end point, colour changes from violet to blue or bright green.

Procedure-

It was estimated by rapid titrimetric oxidation technique. The procedure involved oxidation with a hot mixture of Potassium Dichromate (10 ml) and concentrated Sulphuric Acid (20 ml). Contents were kept at room temperature for 30 minutes to complete the reaction. Blank was also run. After 30 minutes 200 ml distilled water and 10 ml of Orthophosphoric Acid were added. 10 drops of diphenylamine indicator was also added after shaking the contents. Violet colour was obtained. The contents were titrated with Ferrous Ammonium Sulphate solution till the colour changed from violet to blue or light green.

Formula Used-

\[
\% C = \frac{ml \ blank - ml \ titrant \times N \times 100}{Sample \ weight(g)}
\]

Where,

\[N = 0.003\]

Sample weight=2 gram

Total Nitrogen (Singh and Pradhan, 1981)

Nitrogen is one of the macronutrients that is needed by plants for healthy growth, and one that is often lacking in soil. Nitrogen promotes rapid growth, and is important for photosynthesis as it is a part of chlorophyll. Total Nitrogen (TN) is the sum of nitrate-nitrogen (NO\(_3\)-N), nitrite-nitrogen (NO\(_2\)-N), ammonia-nitrogen (NH\(_3\)-N) and organically bonded nitrogen. Total Nitrogen (TN) should not be confused with TKN (Total Kjeldahl Nitrogen) which is the sum of ammonia-nitrogen plus organically bound nitrogen but does not include nitrate-nitrogen or nitrite-nitrogen.

Principle-

The main objective of Kjeldahl method is to convert nitrogen contained in materials to the ammonium form of nitrogen and then determine the concentration of
ammonia-N. Concentrated sulphuric acid, catalysts and salts are used to convert organically bound nitrogen to ammonia. The addition of catalyst aids the conversion while addition of salt elevates the temperature of acid-sample mixture, speeding up the digestion.

Procedure-

It was estimated by Kjeldahl’s method, in which sample was digested with digestion mixture (Potassium Sulphate: Cupric Sulphate: Selenium in ratio of 100:20:1) and 10-15 ml of concentrated sulphuric acid was added, the catalyst mixture was raised to the boiling temperature, promoting conversion from organic-N to ammonium-N. The sample was digested till a bluish green residue was obtained. The contents were cooled and the volume was made up to 100 ml with distilled water. From this 10 ml of the digested sample was taken in a micro distillation flask and 10 ml distil water was added. The outlet of the condenser was dipped in 25 ml of 4% boric acid solution in a 250 ml conical flask. 10 ml of 40% sodium hydroxide was added to the distillation flask and the contents were distilled. After complete distillation, the boric acid was titrated against 0.05 N sulphuric acid till pink colour appeared. A blank was also run and titrated similarly and percentage of nitrogen was calculated using following formula:

Formula Used-

\[
\%N = 14.01 \times N \left( \frac{\text{ml titrant-ml blank}}{\text{Sample weight(g)}} \right) \times 1000
\]

Where,

N=0.1

Sample weight=0.2 gram

Digestion of the samples

For nutrients other than N, the plant materials can be digested in a Diacid mixture or a triacid mixture. The Diacid digestion is used for the determination of P, K, Ca, Mg, S, Fe, Mn, Zn and Cu. It must be followed for determination of Ca and Mg. Since H₂SO₄ can contribute some micronutrients and heavy metals, diacid digestion is normally recommended for plant analysis.
Diacid Digestion

It was carried out using 9:4 mixture of HNO₃:HClO₄. One gram ground plant material was taken and placed in 100 ml volumetric flask. 10 ml of acid mixture was added to it and the content of the flask were mixed by swirling. The flask was placed on low heat hot plate in a digestion chamber. Then the flask was heated at higher temperature until the production of red NO₂ fumes ceases. The contents were further evaporated until the volume was reduced to about 3 to 5 ml but not to dryness. The completion of digestion was confirmed when the liquid became colourless. After cooling the flask, 20 ml of deionized or glass distilled water was added. Volume was made up with deionized water and the solution was filtered through Whatman No.1 filter paper. Aliquots of this solution were used for the determination of P, K, Ca, Mg, S, Fe, Mn, Zn, and Cu.

Phosphorus Estimation in Acid Digest (Bhargava and Raghupathi, 1993)

Phosphorus is another important plant nutrient which is found in high concentrations in vermicompost and majorly used as a constituent of fertilizers for agriculture and farm production. In the form of phosphate it is required by all living things and is often a limiting nutrient for crops. It encourages plant bloom and fruiting.

Principle-

Orthophosphates react with ammonium molybdate ammonium vanadate in HNO₃ medium and gives a yellow colour complex. The colour develops in about 30 minutes and remains stable for 2 to 8 weeks. Intensity of colour is measured at 420 nm in a UV Spectrophotometer (Shimadzu UV-1800).

Procedure-

10 ml of aliquot was transferred to 50 ml of volumetric flask. 10 ml of nitric acid and vandomolybdate reagent were added and mixed. The volume was made upto 50 ml with distilled water. The yellow colour thus formed was read after 30 minutes at 420 nm in a (Shimadzu UV-1800) UV spectrophotometer.

Preparation of standard curve-

0, 1, 2, 3, 4, and 5 ml of standard solution were transferred to 50 ml volumetric flask to get 0, 1, 2, 3, 4, and 5 ppm of P respectively. 10 ml of
vanadomolybdate reagent was added to each flask. The volume was made up with deionized water and shaken thoroughly. The transmittance or absorbance of solution was read after 30 minutes at 420 nm with spectrophotometer or colorimeter using blue filter. Absorbance against concentration was plotted. Once a linear calibration was established, the slope of the curve was determined and then the concentration of the unknown solution was calculated by using the equation $A = mc$

Where,
- $A = \text{Absorbance}$
- $m = \text{slope}$
- $c = \text{concentration}$

Absorbance = slope × concentration

ORs

Concentration = Absorbance divided by slope

Formula Used-

$$\% \ P = \frac{\text{sample concentration (ppm)} \times \frac{1}{\text{Sample weight (g)}} \times \frac{100}{\text{aliquot(ml)}} \times \frac{\text{final volume (ml)}}{10000}}{\text{}}$$

Where,
- Sample weight = 1 gram
- Aliquot = 10 ml

**Determination of Exchangeable Potassium (Bhargava and Raghupathi, 1993)**

Potassium is the third macronutrient important to plant growth. Vermicompost contains concentrated potassium. It is used as a fertilizer in agriculture, horticulture, and hydroponic culture in the form of chloride ($\text{KCl}$), sulfate ($\text{K}_2\text{SO}_4$), or nitrate ($\text{KNO}_3$). Potassium in vermicompost help plants fight diseases, aids in photosynthesis and encourages fruit production.

Principle-

The most common method used for K determination is by flame photometry. It is based on the principle that atoms of some specific element take energy from flame and get excited to the higher orbit. Such atoms release energy of a wavelength
which is specific for that element and is proportional to the concentration of atoms of that element.

Procedure-

The most commonly used method used for K determination is by flame photometry. The digest was diluted to the suitable concentration range so that final concentration lied between 0 to 5ppm. The samples were then read in flame photometer (TMF 45) at 548 nm wavelength or using filter for K.

Formula Used-

\[
\% \text{ K} = \frac{C(\text{ppm}) \times \text{volume of digest}}{\text{Sample weight (g)}} \times \frac{100}{100000}
\]

Where,

Sample weight = 1 gram

**Calcium and Magnesium Estimation (Cheng and Bray, 1951)**

Exchangeable Calcium and Magnesium give reasonable good estimates of potential nutrient availability in plants.

Principle-

Both Ca and Mg may be titrated at pH 10 using Eriochrome Black T as an indicator. Magnesium forms Mg(OH)\(_2\) at pH 12 or higher if NH\(_4^+\) salts are present, thereby allowing calcium to be titrated using Murexide as an indicator.

Procedure-

Estimation of Ca: 2 ml of digested sample was taken, it was diluted to 25 ml and 0.25 ml NaOH and 50 mg ammonium purpurate indicator were added. Solution turned pink. Titration was carried out with 0.01M EDTA solution to determine the end point.
**Material and Methods**

**Ca + Mg Estimation**

**Principle**-

The calcium and magnesium is titrated with std. EDTA solution at pH 10. The calcium plus magnesium concentration is calculated from the volume of std. EDTA solution required for titration.

**Procedure**-

2 ml of digested sample was taken, it was diluted to 25 ml and 0.5 ml of buffer solution was added with 3 or 4 drops of Eriochrome Black T indicator. Solution turned wine red. Solution was then titrated with 0.01M EDTA to determine the end point (Blue or green).

**Formula Used**-

\[
\text{meq/l of Ca or Ca +Mg} = \frac{\text{ml of versenate solution used} \times N \times 500}{\text{Aliquot (ml)}}
\]

Where,

\[
N = 0.01
\]

\[
\text{Aliquot} = 2 \text{ ml}
\]

**Statistical Analysis**

In the present study, data was analyzed using Statistical Package for Social Sciences (SPSS) version 17.0. All the investigations carried out for a particular parameter were repeated three times and mean values were calculated. The significance of the difference between the mean values of parameters for vermicompost and compost samples was analyzed by “t” test. A significance level of \( p \leq 0.05 \) was considered throughout the study. The mean levels of vermicompost samples of different groups were separately analyzed by one way Analysis of Variance (ANOVA). Post Hoc Test was also done to find out the exact point of difference and to tell which groups differ from the rest.
B. Handmade Paper Making

The floral waste generated from temples can also be used for making handmade paper, natural holi colours, rose water, essence, natural dyes, incense sticks, mottling of paper and various ornamental purposes. In the present study, besides vermicomposting the floral waste was also utilized for making handmade paper and mottling.

Experimental Design

Preparation of the raw material- The flowers were collected from the temples. They were segregated and shredded. The flowers were then left for 2-4 hrs. to maintain same moisture level.

Moisture in the raw material- The flower sample was taken in a petri dish and kept overnight in a hot air oven and weighed.

Pulping – Four sets of experiments were made.

<table>
<thead>
<tr>
<th>Set</th>
<th>Treatment</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Chemical</td>
<td>10%</td>
</tr>
<tr>
<td>A2</td>
<td>Chemical</td>
<td>5%</td>
</tr>
<tr>
<td>B1</td>
<td>Enzyme</td>
<td>1%</td>
</tr>
<tr>
<td>B2</td>
<td>Enzyme</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

The study involved the following steps-

Treatment of waste

Set A1 and A2- Flowers were soaked in a cauldron filled with 10% and 5% caustic soda solution and fresh water respectively (Figure 21). They were cooked for 1 hr at 100°C (Figure 22).

Set B1 and B2- Enzymes were added 1% and 0.5% respectively (Figure 23).
Material and Methods

Figure 21: Waste treated with caustic soda

Figure 22: Cooking of Waste
The cooked and enzymatically treated fiber were drained off with a basket sieve and then washed under running water. This removed the slimy soapy feeling as much as possible (Figure 24). During washing under the running tap, much of colour was washed off leaving a golden colour to the fibre. Cooking with alkali helped to remove all non cellulosic material from the flowers. The fibre was left to drain off in the basket sieve for about an hour. After that remaining water was squeezed manually (Figure 25). Waste was then shredded (Figure 26).
Material and Methods

Figure 25: Waste after draining water

Figure 26: Shredding of waste
Beating

The washed pulp obtained from the digester was subjected to the beating process. The degree of beating was controlled through the Canadian Standard Freeness (CSF) measurement. The obtained pulp was beaten to a CSF value of 350 ml (Figure 27). The pulp was collected after beating (Figure 28).
Material and Methods

- **Canadian Standard Freeness (CSF) method**

  A disintegrated pulp sample was diluted to a stock concentration of 0.3 + 0.002%. The funnel and drainage chamber were cleaned and the drainage chamber was placed in position. The receiving funnel was placed in a position as the recipient of the discharge from the side orifice. While stirring, 1000 + 5 ml of homogenous pulp suspension was transferred in a clean graduated cylinder. Bottom of the chamber was closed followed by opening of the lid and air cock. Five seconds were allowed to elapse from the time of pouring the stock and then air lock was opened to start the flow. When the discharge from the side orifice was stopped, volume of this discharge was noted and reported as the CSF value of the pulp.

- **Sheet making**

  The test sheets were prepared using the sheet former method (Figure 29). For this, the beaten pulp was disintegrated and the stock obtained was diluted to a concentration of 0.2 to 0.5 % and its consistency was determined.

---

**Figure 29: British sheet former**
Sheet forming

The drain valve was closed. The inlet valve was opened to wash the wire. The upper section was clamped in position. When the water rose to 50 mm above the wire screen, the amount of stock was added to a grammage of sheet 60.0 ±3.0 g/m² calculated on an oven dry basis. The water was mixed with suspension and filled up to the mark by inserting the stirrer and moving it briskly up and down six times and slowly withdrawing the stirrer. After 10 seconds, the drain valve was opened. When the water left the wire screen, the sheet was formed. The two blotters were placed with side up over the sheet on the wire. The couch weight was placed gently on the blotter and the roll was moved backwards and forwards across the plate. Five complete rolls were made in 20 seconds and the couch roll was lifted up from the middle of the plate and the test piece was carefully separated (Figure 30).

Pressing

The laboratory sheet was placed to the couch blotter and one dry blotter was placed on the top for pressing. The drying plate was placed on top of the test piece with its polished side facing down. The sheets were then placed in the press (Figure 31).
Drying
The sheets were kept at normal air circulation overnight. For this, the sheets attached on the drying plates were kept on the drying rings. The sheets were then separated from the drying plates. The sheets were not allowed to shrink during drying.

Analysis of Strength Properties of the pulp
Strength properties of paper were measured according to the methods given by Technical Association of Paper and Pulp Industry (TAPPI).

Experimental Protocol
The handmade sheets prepared were tested in the Paper Testing laboratory, Kumarrappa National Handmade Paper Industry (KNHPI) by skill operators for the following parameters using TAPPI standard test methods as given below:

Tear Index
Tear strength is the force required to tear a sheet of a paper under standard conditions. Tearing resistance reveals the performance of a paper in various situations; such as assessing web runnability, regulating the quality of newsprint and characterizing the toughness of packaging papers where the shock absorbing capability is essential.
The tearing resistance of a paper is mainly determined by two factors:
1. The force required to split individual fibres.
2. The force required to detach unbroken fibres from their surrounding structure.

Tear index is calculated by dividing tearing strength by grammage and is expressed in mN.m^2/g.

\[
\text{Tear Index} = \frac{\text{Tearing Strength}}{\text{Grammage}}
\]

Tear Index was measured by Tear Tester (Figure 32) using ISO1924 test method (Table 6).

![Figure 32: Tear Tester](image)

**Tensile Index**

The tensile index is also a measure of innate strength of a paper and is similar to the concept of breaking length. Tensile strength is a significant measure of the fibre strength, fibre bonding and fibre length. Tensile strength of a paper can be used as an indicating factor of its ability to resist web breaking during printing or converting.
Material and Methods

It is the tensile strength divided by grammage is expressed in Nm/g.

\[
\text{Tensile Index} = \frac{\text{Tearing Strength}}{\text{Grammage}}
\]

Tensile Strength was measured by Tensile Strength Tester (Figure 33) using T411 method (Table 6).

![Figure 33: Tensile Strength Tester](image)

**Burst Index**

Bursting strength is a measure of the resistance of a paper to break when pressure is applied to a side by a specific instrument. Bursting strength represents the extent of pressure a paper can endure before rupture. It is an important factor to be considered for making paper bags. Burst index is calculated by dividing bursting strength by grammage and is expressed in Kpa.m²/g.

\[
\text{Burst Index} = \frac{\text{Bursting Strength}}{\text{Grammage}}
\]
Burst Index was measured by Burst Strength Tester (Figure 34) using T491 method (Table 6).

![Figure 34: Bursting Strength Tester](image)

**Folding Endurance (Double Fold)**

It is the capability of a paper to bear multiple folds before it breaks or it can also be defined as the number of double folds that a strip can withstand under a specified load before it breaks. Length and flexibility of the fibres contribute to high folding endurance. Folding endurance has been found useful in measuring the degeneration of paper with time. It is significant for printing grades where paper is exposed to multiple folds like in books, maps, or pamphlets. Fold test is also important for carton, box boards and cover paper etc. High folding endurance is essential in Bond, Ledger, Currency, Map, Blueprint and Record Papers.

Double Fold, number was measured by Folding Endurance Tester (Figure 35) by using T511 test method (Table 6).
Material and Methods

Figure 35: Folding Tester

Table 6: Methods used for different parameters

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Parameters</th>
<th>Method</th>
<th>Equipment Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tear Strength</td>
<td>ISO 1924</td>
<td>Tear Tester</td>
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<tr>
<td>2.</td>
<td>Tensile Strength</td>
<td>T411</td>
<td>Tensile Strength Tester</td>
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<tr>
<td>3.</td>
<td>Burst Strength</td>
<td>T 491</td>
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<tr>
<td>4.</td>
<td>Double Fold</td>
<td>T 511</td>
<td>Folding Strength Tester</td>
</tr>
</tbody>
</table>
Experimental Plan

Selection of Temples

Regular visit to temples

Data collection through questionnaire

Characterization of waste

Segregation of Flowers

Marigold for vermicomposting

Floral waste was shredded, air dried and precomposted

The earthen pots with the hole at the bottom for aeration were used

Verm beds were prepared by mixing the processed waste with cow dung in different proportions viz., 50:50, 60:40, 70:30, 80:20 and 90:10

Control (floral waste+cow dung) experimental medium was also prepared in the same proportion

Experiments were carried out in triplicates

Pots were left undisturbed for 50 days and regular monitoring was done

Watering was done once in a day

After 50 days vermicompost was collected, sieved, air dried and analyzed

Quality of vermicompost was assessed through analysis

Marigold+Rose for Handmade Paper Making

Collection of Flowers

Sorting and dusting of the flowers

Chopping of the flowers

Air drying of flowers

Boiling the flowers with Caustic soda or treatment with enzymes

Pulp was obtained

Sheet Formation

Drying of the paper

Pressing/Drying

Figure 36. Figure showing the production process of vermicomposting & paper making from flower waste