

## ***CHAPTER V***

## ***SUMMARY AND CONCLUSION***

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In every civilization from time immemorial to the present day, the art of applying colour through dyeing has played an important role in enhancing the beauty of the fabrics. The knowledge and application of colour on textiles is one of the most important steps in fabric development and its utilization.

While science and technology is revolutionizing the whole world and life style, yet the world we live in and the water we use is no more the same as what nature had gifted us with, centuries back. Today the world is endangered with countless environmental hazards. The textile processing and dyeing is one area, which appears to cause enormous damage to the environment. The undue pollution loads created by the use of synthetic dyes and their hazardous and carcinogenic effects have prompted researchers to look for eco-friendly, eco-conservation and eco-protection products. Natural dyes offer an important alternative in this regard.

The main problems with natural dyeing are that the dye uptake is not good and variety and intensity in the colours are not adequate and the colour does not last. Majority of the natural dyes need a mordant in the form of a metallic salt to create affinity between the fibre and the pigment. While the natural dyes are themselves harmless the metallic mordants are not generally eco-friendly. In order to develop a totally eco-friendly natural dyeing process it is necessary to replace the metallic mordants with more eco-friendly mordants. There is an urgent need to explore natural material for sources of dyes, identifying new and rediscovering traditional dyeing methods and examining the processes that have a potential for making natural dyes more eco-friendly and commercially important . Processed and bio mordants may be of use in this regard. The idea of using processed and bio mordants is to reduce the usage of chemicals and to find out their effect on dye colour fastness and intensity related parameters as well as reconstruction and revival of traditional dyeing techniques.

Having these facts and needs in mind, the present study was designed to find out the ability of selected natural dyes using metallic, processed and bio mordants following pre, simultaneous and post mordanting techniques in increasing the dye uptake, colour fastness, colour intensity and eco-friendly nature. Since cotton fibre, which is the purest form of natural cellulose, is bestowed with the versatile properties like its ability to take up a wide range of dyestuff, low cost of production and comfort during wear, cotton fabric was selected for dyeing.

The major objectives of the study were to conduct surveys for finding out the availability and purchase patterns of natural dyes and fabrics dyed with natural dyes, to explore the possibilities of improving the dye uptake, colour intensity and colour fastness and related parameters of selected natural dyes on cotton material and to study the pollution load of the effluent produced while using natural and synthetic dyes and the effect of the natural dye effluent on the growth of selected leguminous plants.

Four major textile cities in Tamilnadu namely Coimbatore, Salem, Karur and Madurai, where a majority of the dyeing units are situated were identified as venues for conduct of the market surveys. For conducting survey, the investigator selected 360 shops among which 120 shops were selected to collect information regarding natural dyes, 120 shops for information on synthetic dyes and another 120 textile shops to find out the information related to the availability of natural dyed fabrics.

The household survey was conducted among 200 households to find out the awareness and preference of naturally dyed fabrics by the homemakers. Socio-economic status of the family, budgeting practices, awareness and extent of use of naturally dyed fabrics, factors influencing purchase of clothing items, type of dyed fabrics preferred and care of those fabrics by the homemakers were the details collected.

Cotton material with plain weave was the most commonly used fabric for various apparel purposes, hence the investigator selected 30s count, plain weave 68 ends and 64 picks/ inch of hundred percent cotton grey material for the study. The mercerized cotton materials were treated with myrobalan solution for better dye fixation and colour fastness.

Annato seed, babool bark, karingali bark, madder root, vembadam bark and red sandal wood were selected and the dye powders procured from a popular and standard shop in Coimbatore city.

Mordants such as alum, copper sulphate and ferrous sulphate and bio mordants such as pomegranate rind powder and amla powder were selected for the pilot study.

Optimum values for dyeing parameters, namely dye concentration, dye extraction time, dyeing time, mordant concentration and mordanting time were arrived at.

The dyed and washed samples were subjected to visual inspection and objective evaluation, colourfastness tests and k/s values. In order to assess the allergic reactions during physical contact with human skin, the investigator selected 54 members who were, sensitive to skin allergy and were asked to wear wrist band continuously for 12 hours for 30 days and report even if they have any minute skin problem.

In the present investigation physico chemical parameters like temperature, pH, TSS, TDS and COD were analysed by using standard methods.

For studying the effects of effluents on plant growth cowpea, horse gram and green gram plants were used. All the pots were kept under uniform conditions of sun light and air and were watered regularly. The germination percentage and vigour index were calculated at the first emergence of the seedlings and subsequently following standard procedures.

Three samples from each set were collected randomly at 30 days, 60 days and 90 days and their shoot length and root length were recorded. Soil analysis with respect to pH, electrical conductivity, nitrogen, phosphorus and potassium was done prior to the day of sowing as well as at the end of the experimental period.

**The findings of the present study are listed in the following pages.**

- ❖ Among the 30 randomly selected shops for getting details about the synthetic dyes there were 19.2 per cent whole sale dealers, 55.8 per cent of retail shops, 25 per cent of small scale (petty shops) dealers.
- ❖ The problems faced with reference to selling of synthetic dyes were difficult in handling synthetic dyes according to 75.5 per cent of the shop owners. Due to its corrosive nature storage of dyes was a problem as expressed by 73.0 per cent of the shop owners. Some of the dyes have a short shelf life, and hence lost their potency according to 68.0 per cent of the shop owners. Creating respiratory problems, polluting the environment and causing skin allergy were the other problems expressed by 53 per cent, 50 per cent and 47 per cent of the shop owners respectively.
- ❖ While the synthetic dyes are on demand in the dyeing industry, due to the inherent problems in handling, storage and health hazards caused, if there was a suitable alternative, people would welcome that alternative dye so that such problems could be avoided.
- ❖ The survey also revealed that 49 per cent of the shop keepers felt that there was a demand for natural dyes, while the rest 51 per cent felt that there was no demand for natural dyes. The natural dyes were purchased by 32.5 per cent of small scale industries, 14.2 per cent of large scale industries, 28.3 per cent of agents, 20 per cent of educational institutions and 22.5 per cent of researchers.

- ❖ The problems which were faced by the shop owners who sold natural dyes were, limited availability, laborious processes involved in processing the dyes, and limited colour availability. These findings confirm that natural dyes are gaining popularity and natural dyes are available to cater to the needs of the customer's inspite of the problems involved. These problems stated above needs to be addressed to make the natural dyes more acceptable.
- ❖ The cost of the natural dyes were relatively much cheaper than the synthetic dyes and even if the process of extraction is taken into account, it will still be lower than synthetic dyes.
- ❖ The naturally dyed fabrics were available in the form of sarees, dress materials and furnishing items. Natural dyed cotton and silk sarees were seen in 30.6 per cent and 20.8 per cent of the shops respectively.
- ❖ Cost was the major factor which influenced purchase of dress material among 72.5 per cent of the families followed by durability by 63 per cent, availability by 62 per cent, washability by 55 per cent and colour fastness by 52.5 per cent.
- ❖ It was heartening to note that 35, 43, 23 and 22.5 per cent of the homemakers preferred natural dyed cotton fabrics for infant wear, toddlers wear, girls and boys wear. Due to the comfort qualities of cotton and non-allergic quality of natural dyes they preferred natural dyed cotton materials for their apparel purposes. For ladies and gents wear 35 per cent and 6 per cent respectively preferred cotton dyed with natural dyes. These results emphasized the fact that most of the families were aware of the availability and preferred natural dyed materials.
- ❖ It was interesting to note that 64.5 per cent and 55.0 per cent, of the selected families felt that cotton fabrics dyed with natural dyes were eco-friendly and non-allergic, 52.4 per cent expressed that these

fabrics were not always available for purchase, while 51.5 per cent felt that these fabrics were expensive, 47.5 per cent felt that colour fastness could not be guaranteed and 37.5 per cent felt that the colours available were limited.

#### ❖ **Visual Inspection**

With reference to evenness in dyeing, brilliancy of colours, texture, lustre and general appearance of the dyed samples vembadam dyed samples without mordant, vembadam dyed sample using metallic alum following pre mordanting technique, annato dyed sample using processed copper sulphate following post mordanting technique, karingali dyed sample using processed copper sulphate following post mordanting technique and red sandal using processed copper sulphate following post mordanting technique recorded 100 per cent acceptance. All the other samples also had recorded above 85 per cent values indicating that process and biomordants following different mordanting technique were equally as good or even better than the samples dyed using metallic mordants following different mordanting techniques.

#### ❖ **Fabric Weight**

Comparison of the different natural dyes using metallic, processed and bio mordants following different mordanting techniques revealed that red sandal and vembadam dyed samples using processed mordants following pre and simultaneous mordanting techniques had recorded the highest gain in fabric weight by 4.01 g (2.85 per cent), while babool and vembadam dyes by 3.34 g (2.37 per cent) came next in the order. Among the bio mordants used in dyeing, babool and madder dyed samples using amla as bio mordant following post mordanting technique had recorded the highest gain in fabric weight by 5.34 g (3.80 per cent).

### ❖ **Fabric Thickness**

Comparison of the different natural dyes using metallic, processed and bio mordants following different mordanting techniques revealed that red sandal and vembadam dyed samples using both processed and metallic mordants following post and pre and mordanting techniques had recorded the maximum gain in fabric thickness by 0.03mm (7.89 per cent). Babool and madder dyed samples using both pomegranate rind and amla as bio mordant following post mordanting technique and annato dyed sample using pomegranate rind as bio mordant following post mordanting technique had recorded the highest gain in fabric thickness by 0.02mm (5.26 per cent).

### ❖ **Tensile Strength (Warp)**

Comparison of the different natural dyes using metallic, processed and bio mordants following different mordanting techniques revealed that madder dyed samples using amla as bio mordant following simultaneous mordanting technique had recorded the highest gain in Tensile strength on warp side by 7 kg/cm<sup>2</sup> (17.50 per cent).

### ❖ **Tensile Strength (Weft)**

Comparison of the different natural dyes using metallic, processed and bio mordants following different mordanting techniques revealed that Babool dyed samples using processed mordants following post mordanting technique had recorded the highest gain in Tensile strength on weft side by 3 kg/cm<sup>2</sup> (8.41 per cent). Annato and madder dyed samples using amla and pomegranate rind as bio mordants following pre and simultaneous techniques respectively recorded 2.33 kg/cm<sup>2</sup> (8.41 per cent) in tensile strength on weft side.

### ❖ **Elongation (Warp)**

Comparison of the different natural dyes using metallic, processed and bio mordants following different mordanting techniques revealed that annato and vembadam dyed samples using both metallic and processed mordants following pre Simultaneous and post mordanting technique and babool and madder dyed samples using metallic and processed mordants following post mordanting techniques respectively had recorded the highest elongation by 0.33cm (9.43 per cent). Annato dyed samples using pomegranate rind as bio mordant following post mordanting technique had recorded the highest gain in elongation on warp by 0.55 cm (14.28 per cent).

### ❖ **Elongation (Weft)**

Comparison of the different natural dyes using metallic, processed and bio mordants following different mordanting techniques revealed that madder dyed samples using amla as bio mordant following post mordanting technique had recorded the highest gain elongation on weft side by 1.43 cm (33.53 per cent), while babool dyed samples using both metallic and processed mordants following post mordanting technique and madder dyed samples using processed mordants following pre mordanting technique had recorded 1.25 cm (29.41 per cent).

### ❖ **Drop Test**

Comparison of the different natural dyes using metallic, processed and bio mordants following different mordanting techniques revealed that among the metallic, processed and bio mordants used in dyeing, madder dyed samples using amla bio mordant following pre mordanting techniques had resulted in a maximum decrease in time taken for drop test, the value being 7.96 sec (63.02 per cent). The madder and vembadam dyed samples using metallic and processed

mordants following simultaneous and post mordanting techniques respectively had recorded next highest decrease in drop test value by 6.96 sec (55.11 per cent).

#### ❖ **Sinking Test**

Comparison of the different natural dyes using metallic, processed and bio mordants following different mordanting techniques revealed that babool dyed samples using pomegranate rind bio mordant following pre mordanting technique had recorded a highest decrease in sinking time by 10 sec (66.66 per cent), while babool and madder dyed samples using processed mordants following post and pre mordanting techniques respectively had recorded 9 sec (60.00 per cent).

#### ❖ **Capillary Rise Test**

Comparison of the different natural dyes using metallic, processed and bio mordants following different mordanting techniques revealed that babool dyed samples using pomegranate rind bio mordant following post mordanting technique had resulted in maximum decrease in time taken for capillary rise by 8.8 sec (67.54 per cent), while annato and babool dyed samples, using processed mordants following pre mordanting technique had taken 8 sec (61.40 per cent) and 7.76 sec (59.55 per cent) respectively.

- ❖ All the samples dyed with the different dyes, without mordanting recorded 89 per cent with respect to colour fastness to various tests. Among the metallic mordants used for dyeing, the colour fastness values ranged between 85.4 per cent to 90.9 per cent irrespective of mordants and mordanting techniques used. With regard to processed mordants used in vembadam and red sandal dyeing, processed copper sulphate using post mordanting technique recorded a maximum value by 98.1 per cent and 96.3 per cent respectively. The rest of the samples recorded values ranging between 85.4 per cent to 98.0 per

cent. As far as the bio mordants were concerned, except amla mordanted annato and madder dyed samples using post mordanting, rest of the pre and post mordanted samples scored a maximum of 98.1 per cent with respect to colour fastness to various tests.

- ❖ Thus colour fastness of the natural dyed samples using processed and bio mordants showed an excellent rating during washing, sun drying and pressing in general for all the samples irrespective of the dyes, mordants and mordanting techniques.
- ❖ Comparison of the colour strength of the dyed cotton samples with reference blanks revealed, that out of the 54 samples using different mordants, different dyes and different mordanting techniques, 32 samples (60 Per cent) had recorded Error  $\Delta E$  indicating the intensity of colour developed was deep while rest of the samples had developed relatively lighter shades. Samples using metallic ferrous sulphate following simultaneous technique (AMFS - 41.01 and MMFS - 41.75) as well as processed ferrous sulphate following simultaneous technique APFS - 43.91 had recorded highest values for  $\Delta E$ . Thus when the colour strength required is more, the specific dyes, mordants and mordanting techniques numerically indicated in the table as 8, 11, 13, 14, 17, 18, 19, 20, 21, 22, 23, 26, 27, 28, 29, 31, 32, 35, 36, 38, 40, 41, 48, 50, 51, 52, 55, 56, 57, 58, 59 and 60 may be employed. (Those items which have given values for  $\Delta E$  ). When colour strength required is less, the rest of the techniques may be employed. These results confirm that it is possible to get deep shades from natural dyes by effectively combining with them suitable mordants and employing suitable mordanting techniques.
- ❖ Effect of physical contact for allergic reactions revealed that there were no allergic reactions on the skin when the naturally dyed fabrics came in to direct physical contact with the skin.

- ❖ The pH values for the natural dye effluents were 4.50 for metallic mordants, 4.70 for processed mordants and 6.25 for bio mordants. Though the pH value of the natural dye effluents varied, they were are still within the prescribed levels of Bureau of Indian Standards. However the pH of the reactive dye effluent was above the prescribed limits.
- ❖ The natural dye effluents obtained from metallic mordanted, processed mordanted and bio mordanted, samples contained 5574 mg/l, 441 mg/l and 285.2 mg/l of suspended solids, while all the values were higher than the levels suggested by Bureau of Indian standards, the suspended solids were very high (5574 mg/l) in the effluent released after using metallic mordants, which may be due to large quantity of dye particles.
- ❖ The dissolved solids content was also much higher in all the dye effluents when compared with BIS, however they were much lower for the processed and bio mordanted effluents (3230 and 2910) when compared with the values obtained for metallic mordanted and reactive dye effluents (6430 and 54220) respectively.
- ❖ In the present study the effluents were taken for analysis and for pot culture study soon after dyeing. However if they had been stored for a week or two and supernatant solution taken for analysis as well as for pot culture study there are possibilities that the physico chemical values might have came down further.
- ❖ Root length of all the three leguminous plants was maximum for seedlings which were fed with 50:50 water and effluent when compared with tap water fed plants and 100% effluent fed plants. These results indicate that when the effluent is mixed with tap water it does not affect the growth of the seedlings and irrigating with 100% effluent should be avoided as it affects the growth of the root.

- ❖ The mean shoot lengths recorded for all the three leguminous seedlings at the end of 90 days indicated that, the seedlings which were fed with tap water had recorded higher values when compared with seedlings fed with 50:50 combination, as well as 100% effluent. However 50:50 combination fed seedlings had recorded values which were much higher than those recorded by the 100% effluent fed seedlings. Thus the effluent should always be mixed with tap water before being released for irrigation.
- ❖ When equal quantities of tap water is mixed with effluent, the germination percentage is reduced only slightly. However when the effluent alone is fed, the germination percentage reduced to 60 and 70 per cent respectively for cow pea and horse gram. The green gram appears to have tolerated the effluent and germination remained at 90 per cent level.
- ❖ Calculation of the vigour index revealed that the same was maximum all the way for all the three seedlings, which were fed with tap water and the index was maximum on the 90<sup>th</sup> day. The vigour index was proportionately less for all the three seedlings which were fed with 50:50 proportion as well as total effluent fed seedlings, the earlier one showing better results.
- ❖ The vigour index recorded by the seedlings fed with 50:50 proportion had recorded values which were only slightly lower than the values recorded by the seedlings fed with tap water. Thus for achieving maximum germination percentage and vigour index it may be advisable to mix the effluent with tap water and feed the same to the plants.

Results of the effects natural dye effluents on the soil composition before and after feeding of the dye effluent revealed that 50:50 dilution with the effluent was effective in promoting the growth of experimental plants.

- ❖ The pH of the soil samples varied between 6.66 (T<sub>2</sub>) to 6.83 (T<sub>3</sub>). The pH values of the soil was less in both the treatments when compared to the initial values. This may be due to the fact that the phenolic compounds which may be present in the effluent interact with microorganisms present in the effluent / soil and reduce the pH of the soil which will actually promote the growth of the plant.
- ❖ The nitrogen is one of the essential nutrients in soil required for the satisfactory growth of crop plants. The available nitrogen content was highest (148 kg / ha) in 50 : 50 effluent treated soil compared to the initial and 100 per cent effluent treated soil and the least value of 106 kg / ha was observed in 100 per cent effluent group.
- ❖ The available phosphours content of soil by 33.4 kg / ha in 50 : 50 T<sub>2</sub> dilution and 34.0 kg / ha in 100 per cent effluent (T<sub>3</sub>) dilution.
- ❖ The available potassium content of the soil was increased to a maximum of 376 kg / ha in 50 : 50 (T<sub>2</sub>) dilution and 317 kg / ha in 100 per cent effluent (T<sub>3</sub>) dilution. The available nitrogen and potassium to the usage of effluent water were due to the natural dye particles to the soil contaminants through the effluent water.
- ❖ It may be concluded that 50 : 50 (T<sub>2</sub>) dilution was very effective in promoting the growth of the experimental plants.

## Conclusion

From the foregoing findings the following conclusions may be drawn.

While there is a demand for synthetic dyes there are inherent problems in handling, storage as well as pollution problems and health hazards which are difficult to overcome. Similarly with the natural dyes, the lack of colour fastness and laborious process involved in dye extraction and limited variety of colour are the problems. These drawbacks of the natural dyes can be overcome by using suitable processed and bio mordants for the different

natural dyes, as has been proved in the present study through visual inspection tests, mechanical tests, colour fastness tests, k/s values and pollution load tests. If we are able to popularise the natural dyes as well as processed and bio mordants and suitable mordanting techniques colourfast materials with the required intensity of colour may be obtained. Using these natural dyes will eventually help in reducing the health hazards and environmental pollution, which are major threats while using synthetic dyes.

### **Recommendations of the Study**

1. Industrialists should be made aware of the advantages of using natural dyes and encouraged to buy and use the same, while consumers may be encouraged to buy natural dyed fabrics.
2. Industries may be encouraged through extending subsidies for utilizing natural dyes with processed and bio mordants.
3. Standard and shade cards should be developed for natural dyes through repeated experiments, so that a ready reckoner is made available giving formulae for deriving synthetic colours with required shades.
4. Further research may be carried out with many other natural dyes available using processed and bio mordants to arrive at a wide spectrum of colours.