CHAPTER - 1

INTRODUCTION
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Colour is such a vital and vibrant ingredient of our existence that it is difficult to imagine what life would be like without it. Colour is one of the elements of nature that made the human living more aesthetic and fascinating in the world. It is supposed to be associated with emotions, human qualities, seasons, festivals and passions in our life. Even in the prehistoric times, our ancestors must have noticed the abundance of a multitude of colours worn by nature. With the growth of civilization, it was realized that most of the colours he saw in nature (Clouds at Sunset, Flowers on Plants etc) were not permanent; the fading of the colours of flowers took place when their petals fell. The green colour of leaves changed in yellow or brown due to ageing. In his urge to make his world colourful, he tried extracting the colours from flowers plants and even animals. He found that these colours could be retained unchanged for a longer period unlike the natural thing wearing these colours. This led to the use of different types of natural colouring matters to dye clothes prepared from different natural fibres such as cotton, Linen, Wool, and Silk etc. He observed that some dyes, which produce intense action on woollen fabrics, did not even stain cotton clothes. A new class of dyes had to be used to dye cotton. Indigo, cutch, logwood, tyrian purple and henna were some of the natural dyestuff used for dyeing cotton fabrics (Shenai and Saraf 1991). This practice was common and prevalent in different periods of history, with the development of civilization; there was improvement in dyeing techniques. In India too, natural dyes had been used for dyeing as well as in cosmetics since prehistoric times (Shrivastava 1989). Use of natural dyes was common in most of the ancient civilizations e.g. India, Egypt, Greece, Aztec and others. In India, the use of natural dyes for dyeing, painting and printing goes back to the historic periods. This has been well established during the excavations of Harrappan culture at Mohenjodaro when a cloth coloured with red dye was found during excavation. The coloured pottery excavated reveals that use of mineral dyes was in vogue in those days. In epics like Ramayana and Mahabharta description of clothes worn by ladies and gents of that
time shows use of various coloured clothes special mention of 'PITAMBAR' a yellow garment used by the gods, is noticeable. Atharveda carries description of natural dyes. Bhrugu samhita is written using natural dyes. The frescos of Ajantha dating as far back as 1st century A.D. are painted with natural dyes. The later frescos evidence the use of colourful garments by men and women alike.

The evidence of use of natural dyes during pre-Muslim and Muslim period (Mediaeval Period) of Indian history is much better preserved in the form of dresses, manuscripts and printing. Some of the records of the court historians (and biographers like Firdausi) are written and illustrated with natural dyes. The palace decoration and the ceiling of the temples of Hallebid and Bellur (In Karnataka) testify dyes. The coloured exquisite silk and Muslin fabrics of India had acquired fame throughout the world during the 16th and 17th centuries.

Importance of natural dyes in the economic life of India in the 18th and 19th century is illustrated by the rising of Indian planters of Champaran in Bihar. This rising also represents a watershed in the history of natural dyes in India.

Evidences are available in literature showing that selection of colour, type of fabrics and techniques of dyeing were known to different civilizations. These have been tabulated here to give an idea about progresses made in making the life colourful.

1.1 Historical Evidences of Natural dyes

After reviewing the history of natural dyes it is considered desirable to study the reasons for the downfall of natural dyes and attempts of revival.
### Table 1.1 Historical Evidences of Natural Dyes

<table>
<thead>
<tr>
<th>Period</th>
<th>Source</th>
<th>Type of the Dye</th>
<th>Type of Fabric and Colour</th>
<th>Reference</th>
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</thead>
<tbody>
<tr>
<td>3000 B.C.</td>
<td>A Cotton string found at Mohenjodaro</td>
<td>Madder</td>
<td>Red</td>
<td>Gulati &amp; Turner (1929)</td>
</tr>
<tr>
<td>3000 B.C.</td>
<td>Excavations of the ancient Harappan sites</td>
<td>Indigo</td>
<td>Blue</td>
<td>Mohanty (1989)</td>
</tr>
<tr>
<td>1500 B.C. - A.D. 638</td>
<td></td>
<td>Cochineal Coccus illicis</td>
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<tr>
<td>1000 B.C.</td>
<td>Vedic Period particularly in the Atharvedic and the succeeding period (d. 1000 B.C. - 500 B.C.)</td>
<td>Kala or Asikani (Possibly Indigo) Maharanjana (Safflower) Manjistha (madder) Lodhra (Symplocos racemosa) Haridra (Turmeric) Lac in the animal dye.</td>
<td></td>
<td>Meera Roy (1978)</td>
</tr>
<tr>
<td>Period</td>
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<td>Type of the Dye</td>
<td>Type of Fabric and Colour</td>
<td>Reference</td>
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<td>------------------------</td>
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<tr>
<td>Post Vedic Period</td>
<td></td>
<td>Kumkuma (Saffron) Nila (Indigo) Kimi (Kermes) and Recona (Bright Yellow substance prepared from Cow's urine) Gairika (red - ochre) Khanjana (Carbon black)</td>
<td></td>
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<td>(c500BC-3rdCentury A.D)</td>
<td></td>
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<tr>
<td>300 B.C.</td>
<td>Chandra Gupta Maurya's region</td>
<td>Safflower</td>
<td>Silk</td>
<td>Gulati (1989)</td>
</tr>
<tr>
<td>Medieval Period</td>
<td></td>
<td>Kampillaka (Mallotus Philippiness), Pottango(Cacsalpinia Sappan) Jutuka (Oldenlandia) Indrogope (Ccchineal) Abhaya (Terminalia Chebula) Amalka (Emblc myrobalan) Bhiringraja (Eclipta prostrata)</td>
<td>Bright pink</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Red</td>
<td>Meera Roy (1978)</td>
</tr>
<tr>
<td>Period</td>
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<tr>
<td>Late Medieval Period</td>
<td>The Beauliew manuscript (C 1734)</td>
<td>Nila (<em>Indigofera tinctoria</em>), Pippala (<em>Piper longum</em>), Ayasan (from iron) Kasesa (Sulphate of iron), Tuttha (Sulphate of copper) Anjana (Sulphate of antimony), Sakala (from cow dung) Tuvani (alum) was discovered.</td>
<td>Blue</td>
<td>Meera Roy (1978)</td>
</tr>
<tr>
<td>18th century A.D.)</td>
<td></td>
<td>The application of iron mordant for the fixation of colour.</td>
<td>Blue</td>
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<tr>
<td>17th Century A.D.</td>
<td></td>
<td>Aluminium mordant for fixation of colour.</td>
<td>Green, Red</td>
<td></td>
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<tr>
<td>18th Century</td>
<td>The Beauliew manuscript (C 1734)</td>
<td>Veg. Dye, - roots of Saranguy or 'Al' printing (<em>Morinda tinctoria</em>) or (<em>Morinda citrifolia</em>)</td>
<td>Cotton Printing in Western India</td>
<td>Schwatz (1956)</td>
</tr>
<tr>
<td>18th Century</td>
<td>Manuscript of Georges Roques,</td>
<td>Chayroot, Indigo</td>
<td>Cotton printing in Ahmedabad - Red, Blue</td>
<td>Schwatz (1956)</td>
</tr>
</tbody>
</table>
1.2 Decline of Natural Dyes

Right up to the end of the eighteenth century natural dyes were the only dyes used for the decoration of textiles, Shakuntala Ramani (1989).

1.2.1 DISCOVERY OF SYNTHETIC DYES

The discovery of first synthetic dye named mauveine by W.H. Perkin in 1856 burst upon the scene like meteorite shower, drowning the soft mellow tones of natural dyes. In spite of the novelty value of their brilliant hues, the early artificial basic dyes, because of their poor - fastness, were not popular and even by the end of that century, were not fully accepted as a substitute of natural dyes.

The real revolution came in 1880 when the dyeing matter present in madder and Indigo were discovered. The two most important natural dyes, were synthesized and marketed successfully in Germany. Apart from replacements by these two main stars in the constellation of natural dyes, the first quarter of the twentieth century also saw the development of the chemical dyes. Verguin produced Magenta in 1859. (Shenai and Saraf 1894). Nicholson discovered the first water soluble acid dye, and Peter Greiss discovered the diazo reaction upon which the azo groups of dyestuffs are based at the close of the Nineteenth century. The dyers and printers had dyestuff suitable for all the fibres then in use like acid, basic, azo, direct and sulphur. Along with the rapid development of artificial dyes like manmade fibres also appeared on the scene. There was a vigorous/rapid development in the technology of printing by the introduction of intaglio roller printing which replaced the traditional crafts of hand block printing or brush painting. Continuous processes drove out the old batch process, and textile manufacture suddenly metamorphosised into a big industry. Germany gained supremacy in the manufacture of dyes and chemicals, establishing foreign economic domination in this area as in other key industries. Even the Indian dyers and printers found the imported synthetic dyes cheaper to use mainly due to the simplified process of application, ease in getting them in standard forms and their greater variety of shades. This gradually led to the decline of natural dyeing.
1.2.2 POOR INFORMATION DISSEMINATION

The conservative nature of craftsman community was also responsible for the decline of the use natural dyes. The craftsman had strict followings. The dyeing was followed by Rangari and printing by Chhipa communities. The knowledge was generally passed on from generation to other by ways of practical training. In no case it was passed on to the craftsman of other community. Further in the process of transfer of knowledge documentation was not done. At times financial returns for the labour input were not adequate and younger generation lost interest in the craft; thus the folk having knowledge of the craft went on declining.

1.2.3 POOR SCIENTIFIC INPUTS

The industry also did not receive due attention from scientists and agriculturists. While the study of plants was done in relation to their pharmaceutical use and as raw materials for industrial production, no effort was made to study them for their being a source of colouring matter. As a result out of hundreds of plant species, which were known earlier as a source of natural dyes, only few are known now.

1.3 Revival of Natural Dyes

During the period of the World War I (1914-18) the various textile industries of the world were paralysed on account of the complete stoppage of the export of synthetic dyes from Germany which practically held the monopoly till then. Investigations were carried on in several institutions and organizations in India to receive the ancient, indigenous natural dyestuff industry. However, these attempts came to stand still with the end of World War I. During the span of 21 years since the termination of the World War I and the beginning of the World War II (1918-39) the textile industry along with dyestuff industry forged ahead by leaps and bounds. The ultimate result was that the indigenous natural dyes which were being used by the artisans practically disappeared from the market, except few centres in Rajasthan, Andhra Pradesh and few remote rural area where the craft is still practiced by the few devoted families of craftsman.
After independence, one of the policies of the Government of India was to revive and preserve the heritage and culture of India. Revival and development of dyeing and printing with the natural dyes was also covered under priorities. Various Government institutions such as the office of the National Handloom Development Corporation, Weavers service centres, voluntary organizations and individual environmentalists are making several efforts to revive the ancient industry, which was heading towards extinction.

1.3.1 ENVIRONMENT AND HEALTH AWARENESS

It is needless to talk about the rampant pollution that is met everywhere in the walk of life.

It is noted that 1.0 million litters, (Kumar et al., 1993), of effluents are discharged by an average sized Textile Mill per day, having about 8000 Kg/day out of daily production. These effluents contain BOD (Bio-Oxygen Demand), COD (Chemical Oxygen Demand), DO (Dissolved Oxygen), RC (Residual Chloride), TDS (Total dissolved Solids), pH alkalinity and acidity of the effluents and various other harmful compounds present in the effluents, which in any case if present beyond the limit of the standard (ISI) cannot be let out on land for irrigation. Neither it is permit table in to public sewers nor it is let out into in land surface water.

1.3.2 POLLUTION CONTROL STANDARD

The Bureau of Indian Standards (BIS) formulated a comprehensive standard in 1981 (IS: 2490) for the maximum discharge limits of various elements and other parameters. The standard takes into consideration the nature and area (in irrigation land, public sewer and inland surface water, e.g. river) for discharge. There is continuous evaluation by Central Pollution Control Board (CPCB), State Pollution Control Board (SPCB), BIS and other relevant authorities for the need of changing the pollution Control Standards. As a consequence, the IS: 2490 has undergone two revisions, viz., 1986 and 1991. The third revision (1991) is currently in force. Mukherjee (1995) [for reference, IS: 2490 (Part I), 1981.]
The textile industry in particular process houses, consume large quantities of energy, water and chemicals/auxiliaries/dyestuff. Careful judicious selection and optimum handling of these inputs must be a primary objective. It may be emphasized that cleaner industries require collective long-term enthusiasm, willingness and commitment on the part of manpower (Gandhi 1995).

It has also been stated that as far as waste treatment is concerned, it must be emphasized that treatments simply convert waste/pollutant from one form to another. For example, dyes and chemicals in liquid effluent are converted to slurry/sludge, which will have to be disposed off either by land filling or incineration. This may again contaminate the ground water. It is, therefore, better not to pollute rather than pollute and treat.

Protection of environment has now become a challenge for the chemical industry (Archita Mukherjee 1999). According to Mehra et al., (1995) Chemical treatment giving due consideration to ecological problems will also ensure lower air/water pollution in the producing country and satisfy the requirements of ISO 9000 which is becoming a prerequisite for future exports. The need is for a commitment by management, technologists as well as marketing Personnel, research scientists and textile speciality chemical manufacturers to cooperate and take effective steps towards the goal. We have to remember that –

"THE AIR, THE WATER, THE SOIL
ARE NOT THE GIFTS FROM OUR PARENTS
BUT
LOANS FROM OUR CHILDREN"

In the words of HRH The Duke of Edinburogh (WWL International President),

"LOOK AFTER THIS PLANET
IT'S THE ONLY ONE WE HAVE"

Clothing is now considered as a second skin. At home, in bed, at work, in car, Toxins in clothing cause worries. Ecology now has three names.

- Production Ecology – Effect of Production processes on people and environment.
- Human Ecology – Effect of textile worn next to skin on human health.
Disposal Ecology – Effect of textile wastes. (Fibres, dyes, auxiliaries, etc.)

On clean environment, Gandhi (1995). However no such attention has been paid on the effect of toxicity in the garments, upholstery and other textile goods, which are coming in contact with the skin, and causing a direct damage to the health like skin cancer, allergy etc. The concept of clean fashion has opened our eyes in new direction. Environmental pollution through textile processing is harmful to the ecological system, no doubt but the most alarming and injurious to health is the presence of toxic chemicals in the finished textiles, especially which are coming in contact with the skin. The concept of eco friendly textile or clean fashion has opened a new challenge to the industry (Chakrabarty and Basu 1995).

Men are using textile materials since primeval times, which has now become essential to standards of living like food and habitation. This long time intimacy between man and textiles was brought under close scrutiny when Germany imposed a ban on textile products containing certain types of azo dyes effective from April 1,1996. (Anonymous 2000)

Although only 25% of all azo dyes are currently banned in Germany, result from toxicity studies suggest that the percentage will increase significantly in the near future (Singh and Parmar 1998).

The Textile industry in India is also facing the impact of this ban stated Lokhande et al., (1995). Polluting industries in Gujrat have already been asked to re look at their effluent, and in fact some have been forced to stop production. Effects of pollution law enforcement are already being felt in and around Delhi, Maharashtra reported Kamat (1995).

Similarly the hosiery town of Tirupur in Tamil Nadu, have come under tremendous pressure to down their shutters as they have been found violating the pollution norms (Anonymous 1997). Biswas (1998) in the inaugural address on “Environmental Issues: Technology Options for Textile Industry” held at IIT, Delhi emphasized the need of collective and “total” approach for solving the ever increasing environmental problems facing India. Examples of Tirupur and Pali have been cited where the ground water pollution due to textile effluent could be controlled by the concerted efforts of various agencies.
The annual meeting of the International Textile and Apparel Association, focused upon safety, health, and environmental issues in the textile industry. They further highlighted the biodegradability of bagasse geotextiles, and the safety of amateur dyeing (Epps 1998).

In the present global scenario, if the textile industry wishes to bring prosperity through diversification and modernization, they have to manufacture eco friendly product.

According to Nair, (2002) producing eco labelled and environment friendly products and production methods are the factors that are going to guide future market.

Although definition for eco friendly textiles is yet to be standardized, it is generally accepted that if the biodegradability of effluent is more than 90% the product will be eco-friendly. Moreover, several eco labels are available which give consumer a legal assurance that the goods purchased contain no toxic substances or that they do not exceed specific limits; stated Gandhi (1995).

The above definition clearly indicates that, without biodegradation the environmental burden would be enormous.

The depletion of natural resources, ecological imbalances, pollution problem and the disturbed environment due to excess usage of hazardous chemicals and particularly synthetic dyes forced scientists to think of safer alternatives. Natural dyes appear to be the ideal choice (Bhawana Ghorpade 2000). Similarly Nalankilli (1997) stated that, Natural dyes are heading towards a renaissance due to the health problems from man made dyestuffs.

This may be due to the fact that, natural dyes have better biodegradability and generally higher compatibility with the environment. They are non-toxic, non-allergic and non-carcinogenic. Above all it saves energy because the raw materials are not petroleum products.

A study conducted by the Industrial and Technical Consultancy Organisation Of Tamilnadu L.t.d., (ITCOT) has concluded that a high potential exists for Indian natural dyes both in domestic and export markets. “India, with its rich tradition of natural dyes, should have faced the recent ban on azo dyes in textile goods, with far more courage, rather than buckling under pressure. Based on the study, ITCOT has
brought out a report titled “Eco-friendly Export – Oriented Projects in Natural Dyes” for the benefit of those who are looking at alternative investments besides creating an awareness of the intrinsic strength of the country in natural dyes (Anonymous 1997).

1.4 Classification of Natural Dyes

Natural dyes on the basis of their origin can broadly be classified as: plant or vegetable dyes. Insect dyes, and mineral dyes. Plants are the major source of natural colourants. The different parts, such as leaves, flowers, petals, stems, barks, roots, fruit seeds and rinds are used.

The widely known insect or animal dyes are cochineal, and Kermes. Lac is the secretion of the tiny insects Coccus laccae thriving on host plants.

The commonly used mineral dye is Geru (red ochre) (Doraisamy and Janakiraman 1999).

Substantive dyes and adjective dyes is the classification of natural dyes given by Bancroft in his ‘Treatise on Permanent Colours’, published about 160 years ago.

The dyes such as indigo, orchill and turmeric etc., which dyes the fibres directly, are classified as substantive dyes.

The Adjective dyes are nothing but mordant dyes, which are applied on materials mordanted with metallic salts.

Examples of such dyes are logwood, madder, cochineal and fustic.

The above classification was replaced by an equivalent subsequent classification.

1.4.1 DIRECT DYES AND MORDANT DYES

The direct dyes may be further classified as direct dyes for cotton, direct dyes for silk and wool: acid dyes and basic dyes. The direct dyes for cotton dye all natural textile fibres; the acid dyes are mostly only applicable to wool and silk; while the basic dyes have a direct affinity for wool and silk, and tannic acid treated cotton.

Hummel classified the dyeing matter as Monogenetic and Polygenetic dyes.
Monogenetic dyes produce only one colour irrespective of the mordant present on the fibre. Polygenetic dyes produced different colours according to mordant employed e.g. logwood, alizarin, fustic and cochineal.

1.4.2 CLASSIFICATION ON THE BASIS OF APPLICATION PROCEDURE

Gulrajani (1992) has given a classification of natural dyes on the basis of their application procedure. The procedures of application of these dyes are similar to those followed in the case of synthetic dyes.

Direct Dyes

The untreated cellulosic fibres absorb these dyes. There are so many natural dyes belonging to this category. Turmeric and Annatto are the examples of direct dyes. Fibres dyed with natural direct dyes are normally treated with metal salts. They are generally fugitive in nature. Carthamine obtained from safflower is also an example of direct dyes.

1.4.2.1 Acid dyes. Acid dyes are the direct dyes for polyamide fibres like wool and silk. Acid dyes are applied to the substrate from acidic medium; majority of the natural dyes belonging to this class have carboxylic acid groups as against the sulphonic acid groups contained in the artificial colourants. The natural dye saffron has been classified as an acid dye, which contains two carboxylic acid groups. The acid dyed materials are usually subjected to an after treatment with tannic acid and tarter emetic, known as back tanning, which enhances the wash fastness.

1.4.2.2 Basic dyes. They are the cationic dyes, which on ionisation give coloured cations. They are used on polyamide fibres like wool and silk from neutral or mildly acidic conditions. These dyes may also be applied on cotton mordanted with tannic acid and tartar emetic or other metal salts. These dyes have very low light fastness. The dye barberine belongs to this class.

1.4.2.3 Mordant dyes. Mordant dyes are defined as those dyes, which have affinity for mordanted fibres, all dyes, which form complex with mordants, are grouped under mordant dyes. Formation of metal complexes on the fibre may also be achieved by simultaneous application of the mordant and the dyes or by an after treatment.
There are several natural dyes belonging to this class and many natural dyes are extracted along with the tannin from the vegetable matters in which case the dye is directly taken by the untreated cellulosic materials.

1.4.2.4 Vat dyes. The vat dyes derive their name from the wooden fermentation vessel called ‘Vat’ which was at one time used for reducing the dye and converting it into soluble form. The process of soluballisation of the dye is known as ‘Vatting’ and the soluble form of the dye is called leuco dye. The soluble leuco form has affinity for natural fibres, which can be oxidized back on the fibre on exposure to air. Treatment of the material with hot soap solution gives the true colour. Indigo is a classical example of a natural vat dye.

1.4.2.5 Disperse dyes. The chemical structures of many natural dyes are similar to those of synthetic disperse dyes in the sense that they do not have solubalizing groups and are only sparingly soluble in water. These dyes have hydroxyl and/or amino groups, which imparts some solubility to the dye molecule. Many other flavones and anthraquinone dyes can qualify to be classified as disperse dyes. They can be applied on hydrophobic fibres such as polyester and nylon. Furthermore, these dyes can be directly dyed on wool and silk since these dyes also have some limited affinity for wool and silk fibres. However, these dyes can be fixed onto the fibres by post-mordanting treatment with salts.

1.4.3 CLASSIFICATION ACCORDING TO CHEMICAL CLASSES

The colour Index lists 32 red natural dyes, 28 yellow, 12 brown, 6 orange, 6 black, 5 green and only 3 natural blue dyes. Out of 92 natural dyes listed in the colour index, chemical structure of 67 dyes is known. Many dyes have more than one compound and some dyes have identical structure.

The organic dyes and pigments cover a wide range of chemical classes.

1.4.3.1 Indigoid dyes. This is perhaps the most important group of natural dyes. The dyestuff is extracted from Indigofera tinctoria, a bush of the Pea family. The dye was used prehistorically in India, where it probably originated. The word is derived from “Indicum”. The dyestuff is extracted from the plant, which grows to three feet height and has a maximum dye content of 0.4%. The dyeing matter is
present in the form of soluble glucoside known as ‘Indica’. Woad is a blue dye similar to indigo and can be obtained from fleshy leaves of the plant *Isatis tinctoria*.

1.4.3.2 Anthraquinone dyes. Some of the most important red dyes are based on the anthraquinone structure. They are obtained both from plants as well as insects or animals. These dyes are characterized by good fastness to light. They form complexes with metal salts and the resultant metal complex dyes have good wash fastness (Mary Jacob 1999).

A very interesting characteristic of plants containing red pigments is the similar dyeing properties exhibited by plants belonging to the same botanical family for e.g. Plants belonging in the family Rubiaceae have been used in India and elsewhere for imparting various shades of red, scarlet, coffee brown and mauve to cotton and woollen fabrics. Another important property is that these pigments are themselves present in groups, sometimes very large, in the plants containing them; for example up to nineteen pigments having anthraquinone basic structure have been identified in the roots of madder belonging to the genus Rubia (Deepti Gupta 1992).

1.4.3.3 Alpha – napthoquinones. The most prominent member of this class of dyes is obtained from the leaves of *Lowsonia inermis*, cultivated mainly in India and Egypt. Another similar dye is Juglone obtained from the shells of unripe walnuts.

1.4.3.4 Flavones. Flavone’s consists of two benzene rings joined together by pyrone ring. The different compounds when attached to this structure give pale yellow colours quite light but very fast to light and washing. The more the constituents it has the more is the intensity of colours. The flavones can be classified into flavonoids, isoflavone, chalcones and aurones. Flavones comprise a very important class of plant pigments, which are widely distributed in the vegetable kingdom especially as glycosides, but frequently in the free state or associated with tannin. e.g. Luteolol, extracted from woad, for yellow colour.

1.4.3.5 Chalcones and Aurones. These pigments offer tones from orange to orangish red. In plants they are often associated in pairs. Butein from the petals of Dahlia and Rottlerin and its hydroxy derivatives are extracted from kamala, (*Mallotus Phillippinensis*).
1.4.3.6 Carotenoids. The class name being derived from the orange pigment found in carrots, carotene. In these the colour is due to the presence of long conjugated double-bond chains. Crocetin the yellow pigment found in the stigma of saffron and harshingar’s flowers and the pigment occurring in the seed covering of annatto.

1.4.3.7 Diaroyl methane group. There is only natural pigment belonging to this class and that is ‘curcumin’ extracted from the rhizomes of turmeric (Curcuma longa).

1.4.3.8 Alkaloids. There is only one natural basic dye berberine, which is an alkaloid. It turns brownish yellow on exposure to light. The root, barks, stems, are rich in alkaloids essentially berberine, accompanied by its hydroxylated derivatives as carbinol form, aldehyde form and ammonium form.

1.4.3.9 Anthocyanidins. The naturally occurring members of this class include carajurin obtained from the leaves of Bignonia chica, which is direct dye for cotton and wool. It gives bright orange shade.

1.4.3.10 Dihydropyrans. Closely related in chemical structure to the flavones are substituted dihydropyrans like hematin and its leuco form, hematoxylin. These are the principal dyeing bodies of logwood and are historically, the most important natural dyes for dark shades on silk, wool and cotton. Brazil wood is closely related in chemical structure of logwood. Leucoform Brazilin and its oxidized form brazilein have been identified.

Plants, the majority of these are used only locally by primitive peoples secrete over 2000 different pigments. A comparatively smaller number about 150 have been used now (Sharma 1998).

1.5 Dye Yielding Plants Selected for the Study

Three phytochemically rich plants selected for the present study with their families, genus, species, chemical constituents, favourable habitats and medicinal along with other uses have been considered important and discussed separately.
1.5.1 Carissa Carandas Linn

- Hindi Name - Karaunda
- Marathi Name - Karvanda
- Family - Apocynaceae

1.5.1.1 Habitat and general features. An indigenous evergreen shrub or a small crooked tree up to 3 meter in height with dichotomous branches armed with simple or forked 2-4 cm long axillary thorns, found throughout India; Bark yellowish brown, peeling in square flakes; leaves leathery, light green, elliptic or elliptic-oblong, rounded at both ends; flowers white or pink, faintly scented, berries ellipsoid, purple or pink, & white, normally 8 seeded.

1.5.1.2 Distribution and propagation. The tree is suitable for arid tropics and sub-tropics. It is grown for its edible fruits. It grows successfully in marginal and wastelands. The plant is useful for making dense hedges around fruit orchards as it forms an attractive thorny hedge, which can be trained to any height (Purohit 1985-86).

The plants are commonly raised from seeds but can also be multiplied by hard woodcuttings and air layering with the aid of growth regulators. The plants once established, are very hardy and thrive without irrigation and much care but require manuring regularly. They start bearing fruits two years after transplanting.

1.5.1.3 Medicinal uses. The ripe fruits are antiscorbutic, cooling and useful in bilious complaints.

1.5.1.4 Chemical constituent of Carissa carandas. Chemical constituents (pigments) of the Carissa carandas fruits could not be traced from secondary data. Only an unknown alkaloid from the fruits is reported (Anonymous 1992).

1.5.2 Holarrhena Antidysenterica Linn

Hindi Name - Kurchi
Marathi Name - Kuda, Pandhara kuda, dola-kuda
Family - Apocynaceae

A deciduous shrub or small tree 30-40 ft.
1.5.2.1 Habitat and General Features. Holarrhena antidysenterica is a small to medium size deciduous tree, attaining a height of forty feet. Tall shrub bearing fairly large, opposite, short petioled membranous ovate oblong, prominently veined leaves; cymose clusters of large white some what fragrant flowers, and pairs of narrow slender, foot (20cm.) long pendulous follicles. Usually white spotted seeds light brown, coma brownish. It flowers at different times at different parts usually from February to May or occasionally in June to July, and September to November.

1.5.2.2 Distribution and Propagation. The plant is found throughout the drier or deciduous forest area of India up to an altitude of 4,000ft. It often grows gregariously. It can be successfully grown in the most reclaimed wasteland with moderate rainfall (Gopal and Chauhan 1996). The species is important in re-clothing wastelands. It is first to come up and is last to disappear in denude forests. It acts as a nurse to more valuable species, especially Sal seedlings, in forests. It is also cultivated as an ornamental plant for its beautiful flowers, which are borne, in great profusion in spring before the appearance of leaves; a second flush is often produced in September-November. Natural reproduction is abundant owing to regular and copious seeding from an early age. Seeds germinate during the early rains.

Artificial reproduction can be secured both by direct sowing and by transplanting. Fresh seeds have a high percentage of germination but in seeds more than a year old the viability is low. The species is successfully grown by line sowing with field crops. Weeding, periodic thinning, and loosening of soil at intervals are beneficial (Anonymous 1959).

1.5.2.3 Medicinal Uses. Scientists reported number of studies regarding system of medicine with their uses on stem bark, seeds and root bark. Some of the uses of leaves in Yunani medicine were also reported as Astringent, tonic mitigates pain in muscles, cool the brain, useful in cases of chronic bronchitis, lumbago, Urinary discharges, boils, ulcers, wounds, burns, regulating menstruation and for fumigating the mother and child after delivery.

1.5.2.4 Chemical constituents. Dutta et al., (1950) studied the seasonal variation of the alkaloidal content in the plant. The highest content of alkaloid has been found to be soon after the rains. The leaf contains highest amount in June
(1.56%). Janot et al., (1966) reported, Kurchiphylline, Kurchiline, kurchaline, Holadysamine, Holantosines A, B, Holantosine C, D, whereas Qui et al reported Holarosine – A and Holantosines E, F and Holarosine – B have been reported by Goutarel Robert (1972). Daniel et al., (1978) detected 2.3% of tannins in the leaves of kurchi and studied the chemataxonomy of Apocynaceae.

1.5.2.5 Other uses. The floss from the seeds is used for stuffing pillows. It is high-class turnery wood and is suitable for carving. The wood is used for making small articles, such as combs, picture frames, curved boxes, toys, spoons, paper knives, walking sticks, hookah stems, ploughs, beads, mathematical instruments, pins for silk textiles and furniture. It has been recommended for cotton reels, shoe heels, and engraving and printing blocks. The use of wood ash has been reported in Chota Nagpur for dyeing purposes and as a caustic to open abscesses (Anonymous 1959).

1.5.3 TAGETES ERECTA LINN

Marathi Name - Zendu
Hindi Name - Genda
Family - Asteraceae

1.5.3.1 Habitat and general features. A stout, branching herb, 60 cm tall, extensively cultivated as a border-annual in gardens all over India. It is very popular owing to its brightly coloured flowers – lemon yellow to orange. The flowers bloom abundantly from the beginning of summer up to autumn. Leaves strong scented, pinnately dissected; segments 1-5 cm., long oblong or lanceolate, serrate; flower – heads solitary, yellow to orange, 5-10 cm. across; rays many, long clawed, sometimes 2-lipped or quilled, involucre campanulate; achenes 6-7 mm long, pappus scaly.

1.5.3.2 Distribution and propagation. Cultivation is very simple as its major requirements are a nourishing soil and a sunny situation. It is propagated from seeds, which are borne in abundance and by cuttings of fresh stems, planted in moist soil. A crop of T. erecta harvested in full bloom, yielded c.3, 000 kg. flowers and c.30, 000 kg. herb per hectare.

1.5.3.3 Medicinal uses. An infusion of the plant is used against rheumatism, cold and bronchitis, Fresh flowering plants yield aromatic essential oils called...
‘Tagetes Oil’ The oil from flowers is reddish yellow in colour and the oil from the leaves and stem are greenish yellow. The juice of leaves is used for earache. The leaves and florets are used as emmenagogue. The florets are used in the treatment of eye diseases and ulcers. The flower heads are much employed at religious ceremonies for decorative purposes.

1.5.3.4 Chemical constituents. The flowers contain several pigments, which appear to vary with the source of material. Quercetagetin (3:3:4:5:6:7-hexahydroxyflavone) and quercetagetrin-7-glucoside; present only in early-seasons flowers). Several carotenoids have also been identified. Dried and ground florets as well as separated xanthophylls have been used in chicken feeds for enhancing the yellow colour of eggs.

1.6 Mordants

Natural dyes are either ‘Substantive’, needing no mordant, or ‘Adjective’, requiring one. The majority of natural dyes need a chemical in the form of metal salt to create an affinity between the fibre and the pigment. These chemicals are known as ‘Mordant’, the name being derived from Latin mordere, meaning to bite’. It was thought at one time that the mordants ate away the surface of the fibre so that the dye could sink in. A mordant is now regarded as a chemical, which can itself, be fixed on the fibre and which also combines with the dyestuff. A link is therefore formed between dyestuff and fibre, which allows certain dyes with no affinity for the fibre, to be fixed. Where the dyes are capable of being dyed directly, the mordant helps to produce faster shades by forming an insoluble compound of mordant and dyestuff within the fibre itself Gulrajani (1992). Mordants are some specific substances, which increase the adherence of various dyes to the fabrics. The mordanting agents actually form a chemical bridge between the fibre molecules and the dye (Sharma 1998). According to (www.johnmarshal/) Mordanting is adding a substance to the dye source to influence it that is to bringing characteristics that may be otherwise hidden or suppressed. That substance is the mordant. A mordant does not serve as a colour source of it own. A mordant is a substance applied to fibres before dyeing which helps
the dye adhere to the fibres. The type of mordant used will usually affect the end colour of the fabric (www.47.pair.com/lindo/Dyes.htm).

Beside metallic salts, tannins and oils are also used as mordant. Therefore they are classified as:

- Metallic Mordants
- Tannins and Tannic acid
- Oil Mordant

1.6.1 METALLIC MORDANTS

Some of the common mordants are Alum, Potassium Dichromate, Ferrous Sulphate, Copper Sulphate, Stannous Chloride and Stannic Chloride.

1.6.1.1 Alum. Alum is a double sulphate of Aluminium and Potassium, which crystallises in the shape of octahedra with 24 molecules of water of crystallization. This salt is also called Potash Alum \( \text{Al}_2\text{K}_2(\text{SO}_4)_4 \).

Alum is soluble in water and is not dissociated by boiling or by diluting with water. By the addition of alkali temporary precipitates are formed. This solution without permanent precipitation is called neutral alum.

1.6.1.2 Potassium dichromate or Chrome. It is manufactured by heating chrome iron ore with lime and potash, when the atmospheric oxygen oxidizes the chromium oxide, and chromates of calcium and potassium are formed. Potassium dichromate crystallizes in the form of large orange triclinic prisms. It is poisonous, a property common to chromic acid and its salts. The solutions of dichromate are light-sensitive.

1.6.1.3 Ferrous sulphate (\( \text{FeSO}_4\cdot7\text{H}_2\text{O} \)). Is also known as Copperas or Green Vitriol. Ferrous sulphate is prepared on the large scale from the iron pyrites. It is also obtained as a by-product in various manufacturing processes. The commercial product forms bluish green monoclinic crystals, which effloresce in the air and become yellowish by oxidation, though when pure they are perfectly stable. Ferrous sulphate is readily soluble in water and do not dissociate either on heating or on cooling. It is one of the most important and one of the oldest mordants known and is still extensively employed.
1.6.1.4 Copper sulphate (\(\text{CuSO}_4 \cdot 5\text{H}_2\text{O}\)). Cupric sulphate is manufactured by roasting ores, which contain copper, and by dissolving them in sulphuric acid. From this solution crystals having different degrees of purity are obtained. It is readily soluble in water.

1.6.1.5 Stannous chloride (\(\text{SnCl}_2\)) is prepared by dissolving tin in hot hydrochloric acid. From the aqueous solution monoclinic crystals are obtained which contain two molecules of water of crystallization and which are known commercially as tin crystals. Stannous chloride has a fairly high solubility in water.

1.6.1.6 Stannic chloride. It is prepared by oxidation of stannous chloride with chlorine or potassium chlorate.

1.6.2 OIL MORDANTS

Oil mordants are used mainly in the dyeing of Turkey red colour from madder. The main function of the oil-mordant is to form a complex with alum used as the main mordant. Since alum is soluble in water and does not have affinity for cotton it is easily washed out from the treated fabric. The naturally occurring oils contain fatty acids such as palmitic, stearic, oleic, ricinolic etc. and their glycerides. The COOH groups of fatty acids react with metal salts and get converted into \(-\text{COOM}\), where M denotes the metal, for instance in the case of alum it would be \(\text{Al}\). Subsequently, it was found that the treatment of oils with concentrated sulphuric acid produces sulphonated oils which possess better metal binding capacity than the natural oils due to the introduction of sulphonic acid group, \(-\text{SO}_3\text{H}\). The sulphonic acid can react with metal salts to produce \(-\text{SO}_3\text{M}\). The bound metal can then form a complex with the mordant dye such as madder to give Turkey red colour of superior fastness and hue. Thereafter the sulphonated oils were called Turkey Red Oils (TRO).

From the foregoing account it is apparent that the tannins by themselves do not act as mordants but tannin – metal salt combination can only act as a mordant for the natural mordant dyes.

Alternatively, if water soluble salt such as alum is applied to the cotton substrate and then insolubilise this, say by treatment with alkali such as calcium carbonate or sodium carbonate, then an insoluble salt of aluminium is deposited in the
material. The insoluble salt of aluminium provides the metal-chelating sites for the natural mordant dye. This kind of treatment can form the basis to get bright shades of natural metal – complexing dyes. Allegro is perhaps the only natural dye manufacturing company, which is marketing pre-dried aluminium hydroxide gels for use as mordant.

1.6.3 TANNINS

Tannin has been the most widely used mordant ever since the colouration of textiles started. People from Rajasthan, Bihar, Andhra Pradesh (Masulipatnam and Kalahasti), Tamil Nadu and Maharashtra have been using tannin for dyeing and printing, which are still being exhibited, in museums. The famous Kalamkari works in olden days and printing of Multani sarees have been done mostly with tannin.

1.6.3.1 Sources of tannin. While it may be said that almost every plant contains tannin to some extent at least, they are present more amongst the angiosperms, or the higher plants, especially in certain dicotyledons. Important tannin bearing dicotyledon families are leguminosae (e.g. Wattle, Burma cutch), anacardiaceae (e.g. Gulbracho, sumach), Polygonaceae (e.g. Canaigre), rhizophoraceae (e.g. Mangroves), myrataceae (e.g. Eucalyptus).

Tannins (e.g. Babool) are found in the cell sap or in other definite areas in bark, wood, leaves, roots, fruits, and galls. Examples would be bark (black wattle, babool and oak), wood (chestnut and quebracho), leaves (sumac and dhawa), root (canaigre), fruits (myrobalan, pomegranate fruit rind), pods (divi-divi)

Myrobalan. Myrobalan nuts are the unripe fruits of species like Terminalia chebula, Myrobalaneous chebula, T. bellerica (Combretaceae). These trees occur throughout deciduous forests of India. The nuts have tannin content of 30 to 40 percent. The dried fruits resembling a slightly shrived plum, are about an inch long, very hard and posses a bitter astringent taste. The bulk of tannin is in the peel of the fruit. The tannin of the myrobalan is in yellowish brown in colour. It is used in cotton dyeing and black dyeing of silk. It is known as Kadukai in Tamil, Harda in Hindi and Marathi. Pomegranate (Punica granatum; Panicaceae) is a native to Iran; now cultivated throughout India. The round berry like brownish – yellow or reddish fruits
are 2 to 4 inch in diameter. They have a hard rind and edible pulp with amethyst coloured juice and many seeds. Fruit rind and twigs of pomegranate are the source of tannin. The fruit rind contains total tannin 32.8 percent, hydrolysable tannin 22.1 percent prepared by aqueous extraction of rind. Babool (Acacia nilotica, family-Mimosaceae) are found in drier regions of India. Bark is widely used as tanning substance. Bark and pods of babool are exported to Europe from India. The gum of commercial importance is extracted from babool known as gum arabic. Babool serves as a host species for Lac insect, which derives its food from the sap of the trees. Kharbade and Mishra (1999) reported 32.86% and 18.27% tannin yield in Myrobalan and Pomegranate rind respectively.

Tannins are the most important ingredient in the dyeing with natural dyes producing yellow, brown grey and black colours. They also modify the affinity of fibres towards different dyes. A back tanning process improves the washing fastness of some dyes. However, treatment with tannins makes dyeing dull.

Tannins are naturally occurring compounds of high molecular weight (between about 500 to 3000) containing phenolic hydroxyl groups (1-2 per 100 Mw) to enable them to form effective cross-links between proteins and other macromolecules, the term tannins was introduced by Seguin in 1796 to describe the substances present in number of vegetable extracts which are responsible for converting putrescible animal skins into the stable product leather by tanning process.

In the dyeing of textiles tannins form the basis of ‘so called’ natural mordant. As stated above tannins are phenolic compounds, and those tannins, which have o-dihydroxy (catechol) groups can form metal chelates giving different colour with different metals. An after – treatment with metal salts not only alters the light sorption characteristics of tannins but also makes them insoluble in water. Hence they are ‘fixed’ on the textile substrate giving good washing fastness.

Beside these reactions, it is postulated that tannins form following three types of bonds with proteins (such as wool and silk) and cellulose (such as cotton and viscose rayon etc.)
- Hydrogen bonds between the phenolic hydroxyl groups of the tannins and both the free amino and amido groups of the protein, or the hydroxyl and carboxyl groups of other polymers.
- Ionic bonds, between suitably charged anionic groups on the tannin and cationic groups on the protein.
- Covalent bonds formed by the interaction of any quinone or semiquinone groups that may be present in the tannins and any suitable reactive groups in the protein or other polymer.

The stability of the tannin – fibre bond depends on the pH, ionic strength and metal chelators.

The vegetable tannins may be divided structurally in to two distinct classes depending on the type of phenolic nuclei involved and the way they are joined together.

1.6.3.2 Hydrolyzable tannins. Tannins of this class are characterized by having as a core a polyhydric alcohol, such as glucose, the hydroxyl groups of which are esterified either partially or wholly by gallic acid or its congeners. Tannins having this structure can be readily hydrolysed by acids, bases or enzymes to yield the carbohydrate and a number of isolable crystalline phenolic acids: thus they are called hydrolyzable tannins.

The other acid isolated from hydrolysable tannins is ellagic acid. Therefore some times the hydrolysable tannins of vegetable origin are divided into two groups namely gallotannins and ellagitannins. Some of the important raw materials for these tannins are: Myrobalan fruit (*Terminalia chebula*), Pomegranate rind (*Punica granatum*), Oak bark and Wood (*Quercus alba* and other species), sumac leaves (*Rhus typhina*) and Gallnuts (*Quercus infactoria*).

1.6.3.3 Condensed tannins. Tannins of this class contain only phenolic nuclei. On treatment with hydrolytic reagents, tannins of this class tend to polymerise, particularly in acid solution to yield insoluble amorphous often-red coloured products known as phlobaphenes. Most tannins of this type are formed by the condensation of two or more molecules of flavan-3-ols, such as catechin.
Since some of the natural dyes can form metal – complexes and thereby given different colours, there is a tendency to use all type of metal salts for this purpose. The famous ‘German Ban’ has put the restrictions to the use of metal salts. Accordingly the indicative maximum permissible quantities of different metals in the ultimate product are as follows.

As (1.0 ppm), Pb (1.0 ppm), Cd (2.0 ppm), Cr (2.0 ppm), Co (4.0 ppm), Cu (50ppm), Ni(4.0ppm), Zn(20ppm).

The upper limits of the presence of metals vary from product to product and are different for different eco marks. However, there is no upper limit on aluminium iron and tin. The upper limit on Copper is also fairly high. Hence one can safely use these salts for complexing and mordanting. One has to, of course, optimise the quantities so as to minimize the pollution load.

1.7 Need and Importance of the Study

As suggested by the ‘German ban’ use of benign chemicals like Alum, Iron and Tin is the need of the hour. However, the use of natural mordants like Harda, Pomegranate rind, Babool bark is more justified which will not harm the eco cycle.

Use of natural dyes along with safe chemicals can reduce the effluent treatment cost, which will help to reduce the cost of production.

Natural dyes are an ideal choice for a cleaner, less polluting, and cause less damage to the textile substrates. They are obtained from renewable resources with no health hazards. They are Biodegradable. Practically no or mild chemical reactions are involved in their production. Lot of creativity is required to use these dyes judiciously.

It would be fair to justify the need for promoting and using natural dyes for dyeing and printing of natural fibres such as cotton and silk as they are known for their richness, comfort and biodegradability.

Seen from the other angle commercial utility of natural dyes on a large scale for export and domestic markets have not been explored much. However very few attempt have been made to explore the natural resources present in the neighbouring
surroundings. Thus, to meet the demand and requirements of natural dyes for today and tomorrow there is a dire need of taxonomical survey regarding the dye yielding plants specifically of the region to explore them as a potential of commercial dye source.

On the other hand favourable conditions for their propogation and cultivation have to be investigated. To show the feasibility of providing high quality natural dyes from plants, other co-products like the fuel wood, tannin products along with their inherent medicinal properties, need to be traced. Creating new opportunities for both farmers and the fabric industry in line with the current consumers trend towards value added ethnic fabric and natural products is the growing demand of world today.

Keeping this in mind it was considered to be of immense importance to explore the natural resources of the region. Hence in line exploratory survey of the flora of Melghat forest was carried out with the help of taxonomists and economic botanists from the viewpoint of their potential for dye yielding plants, and their appropriate industrial utilization.

While searching for the dye yielding plants, their morphological features, favourable conditions for propagation have been observed and identified, from the viewpoint of cultivation. Through proper cultivation the manufacturers would get assured supply of raw materials and the farmers would get better value for their products.

On the other hand it was also considered important to maintain the delicate balance between supply and demand. Though natural dyes are a renewable source – Trees cannot be grown overnight. Therefore in the present study while selecting the parts of the plants as natural dye sources, care was taken not to harm or destruct the plant growth.

Firstly the matured fruits of Carissa carandas were selected and used to extract the dye. In the present study the crushing of fruits was done manually. The seeds were removed safely and shade dried. The removed seeds may be used for the cultivation of new plants. Carissa carandas grows successfully in marginal and wasteland hence considered vital to explore as a dye source.

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DYEING AND PRINTING OF COTTON AND SILK WITH SELECTED NATURAL DYES

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Secondly the leaves of *Holarrhena antidysentrica* were selected and used which in no way destruct the plant growth. In more holistic view, the cenasing leaves, which otherwise fell down were also tried to compare the dye, yield with that of the leaves of monsoon. *Holarrhena antidysentrica* often grows gregariously. It can also be successfully grown in the most reclaimed wasteland with moderate rainfall hence considered important to explore.

Thirdly the *Tagetes erecta* (Marigold) the flower heads are much used for garlands, medicinal as well as for cosmetic purposes. It is very popular as a garden plant extensively cultivated as a border – annual in gardens all over India. It was a zeal of the researcher that the plant waste should also be used as a dye source one of the commonest among the dye yielding plants, marigold flower heads collected during the month of October were experimented in used (dried) and fresh form.

But the use of Natural dyes alone will not help the environment much because as discussed earlier there is no upper limit over the use of Alum, Iron and tin. However Alum is proposed for its low environmental toxicity (Anon 1995). Alum was selected as a sole mordant used in combination with other metal mordants to partially reduce the quantity by using three different ratios. The use of natural mordants like Harda, Pomegranate rind and Babool bark along with alum as binary mordants combination is more justified, imparting different colours and shading variations to add to the colour palette. Use of natural mordants in the process of natural dyeing and printing will help to create healthy as well as balanced environment; both for human population and flora and fauna of the region.

With due considerations for the imperatives, the present study was directed towards the following objectives.

1.8 Objective of the Study

Literature search has brought to light that not a single study was carried out in the Vidarbha region to explore the regional flora for dye yielding plants. However the 'Melghat Forest’ of Vidarbha region is known for its natural wealth. There are several species of trees and shrubs, which do give excellent dye sources, which were not
tapped as a potential of dye source, therefore it has become a primary objective to do the survey of ‘Melghat forest’

1.8.1 THE SPECIFIC OBJECTIVES

- To optimise the dyeing parameters of selected natural dyes on cotton and silk fabrics.
- To undertake the detailed study for control and experimental group with each selected dye.
- To evaluate the effect of alum as a single mordant and alum in binary combination with metal and natural mordants at three ratios in terms of colours, shade variation and fastness properties.
- To evaluate colour values of dyed samples in terms of L*, a*, b*, c*, h* values.
- To assess the fastness properties of dyed fabrics in terms of control and experimental groups.
- To estimate the cost for dyeing per kg of fabric.
- To assess the viability of printing cotton and silk with selected dye sources.
- To assess the fastness properties of printed fabrics in terms of alum as a single mordant and alum in combination with metal and natural mordant with only one ratio.
- To estimate the cost for printing cotton and silk with selected dye sources.

1.9 Scope and Limitations of the Study

Melghat forest is endowed with a wealth of natural flora which may provides the basic resources for dyes. Secondly, the flora is widely distributed in the tribal belt therefore there is a wide scope to establish the small dyeing and printing unit in the region. Thus leading to the employment generation for the tribal people through value addition to the non-wood forest products with eco friendly standards to fulfil some of the consumer demands. This will also help in preserving the rich tradition of dyeing and printing to some extent.

On the other hand dyes selected for the present study imparted different colours and their shades on cotton and silk. Therefore there is a scope to exploit these
dye sources commercially for domestic as well as export market through research and
development. The scope of the study and resources available to the researcher thrust
certain limitation on the study.

The study was undertaken within a time period of Faculty Development
Programme of U.G.C. UNDER IX plan. Total twelve and half months leave was

- In the present research result of the pilot study were derived by evaluating the
dyed samples on visual basis.
- Only aqueous extraction method was used.
- Optimisation was restricted to only three dye material concentrations and time
  periods.
- Limited mordant combinations and ratios were studied due to limited time.
- The leaves of *Holarrhena antidysenterica* were collected previously in
  September (2001) for pilot study; but the actual experiment was carried out in
  February (2002) due to time limit.
- Exhaust dyeing method was adopted for dyeing and printing.