# *CHAPTER II*

# *REVIEW OF LITERATURE*

# II. REVIEW OF LITERATURE

The review of literature pertaining to this study on **"IMPROVING THE EFFICIENCY OF SELECTED NATURAL DYES ON COTTON FABRIC"** is dealt under the following headings :

2.1. An Overview of Textile Industries
2.2. Cotton as a Clothing Item
2.3. Significance of Pretreatment in Processing Industries
2.4. Role of Colour and Dyeing in Enhancing the Appeal of Cotton
2.5. Different Types of Dyes, their Classification, Characteristics and Extent of Use
2.6. Different Types of Mordants and Mordanting Techniques
2.7. Environmental Pollution
2.8. Need for Improving the Efficiency of Natural Dyes

## 2.1. AN OVERVIEW OF TEXTILE INDUSTRIES

The Indian textile industries occupy an important place in the economy of the country because of its contribution to the industrial output, employment generation and foreign exchange earnings as observed by Sharma (2005). Rushin and Vadhani (2003) point out that it has a 20 per cent share in the country's total industrial production and a 34 per cent share in its total export while providing direct employment to about more than 5 million people. According to Dhandapani and Selladurai (2003) textile industry is the second largest employment provider in India after agriculture sector in both rural and urban areas. The textile industry is a self-reliant industry, starting from the production of raw materials to the delivery of final products with considerable value addition at each stage of processing.

Indian textiles are known for their fine quality and captivating colours and have attracted connoisseurs from all parts of the world for ages. Textiles from India bear the imprint of the fine craftsmanship of Indian weavers and the

exquisite quality of Indian textiles has been hailed from ancient times (Encyclopaedia of Textiles, 2005).

Sarkar (2004) points out that India has a large pool of textile workers experienced in latest technological skills and the Indian textile industry has a strong base in terms of trained scientists, expertise, manpower caliber with entrepreneurial spirit, raw material availability, machinery, equipment, processing, testing and evaluation.

Indian cotton textile industry has a high export potential, because of cost competitiveness which is driving the Indian basic yarns and grey fabrics in international commodity markets. Small and flexible batches of apparels are being manufactured in India and provide a large variety of casual wear and leisure garments at significantly lower price (Rani and Singh, 2004).

The textile industry has undergone a continuous metamorphosis in terms of technology upgradation, especially with the advent of information technology since independence. In this context, the role of research and development has assumed paramount importance and has become one of the key factors for the success of the industry. The Ministry of textile has been assisting the textile committees in setting up of modern textile laboratories to ensure that the textile exported from the country meet all International standards (NITRA, 2003).

Sarkar (2004) points out that textile industry as such is controlled largely by the qualitative and quantitative pattern of demand and this demand for fabrics is influenced by changes in income, growth in population, life style, climatic conditions and fashion cycles. Textile manufacturer aims at catering to the needs of the trade and the needs of the people that change from time to time.

Patodia (2004) reports that the textile industry has been successfully meeting the clothing requirements of the increasing population in India, which has crossed one billion mark and with the rising income and improvement in

standard of living, expectations and aspirations of consumers are also shooting up. It will therefore be a challenging task for the textile industry to meet the changing requirements of good quality clothing at affordable prices. The quality conscious and cost effective units will be able to face the emerging challenges in the national and international arena.

## 2.2. COTTON AS A CLOTHING ITEM

Cotton was first grown about 4000 years ago in India. Prabhaharan and Rao (2003) suggest that the Indian climatic condition and constituents of soil were considered as some of the major conducive factors for the growth of cotton in this part of the Globe. Cultivation of cotton in Europe and other parts of world was started around $7^{th}$ century. Even the invention of various man made fibres, which can be produced with desired properties, are not able to compete with this ever demanding fibre in popularity.

Sivaramakrishnan (2005) acknowledges that India has made enormous strides since independence to become self sufficient in cotton production. Globalisation of economy and the stringent quality requirements to be met by exporting units have particularly made cotton trade and spinning industry highly conscious of the vital importance of high quality cotton as reported by Basu et al. (2003). Raja (2004) points out that the Indian Cotton Mills Federation (ICMF) and Cotton Development and Research Association (CDRA) have come together for creating massive awareness on the new methods of cotton cultivation across the country to enhance productivity, quality and to ensure reasonable prices to the growers during the cotton year 2004-2005. Indian textile industry employs 35 million people and provides one quarter of the country's export earnings. It is estimated to consume 35 million bales of cotton by 2010, as pointed out by Nair and Pandian (2005).

Basu et al. (2003) point out that in a span of 150 years, Indian cotton textile industry has recorded significant progress. Today India has about 37.08 million installed spindles capacity with the help of which 2204 million kg

of cotton yarn is produced per annum. India is the world's third largest producer of cotton, has risen by nearly 25 per cent which proves that (consumption is improving) and we should be able to use most of the cotton produced this year, views Nair and Pandian (2005).

Cotton is the first major and world's leading textile fibre with some 20 million tonnes grown every year by about eighty producing countries, observe Sharma et al. (2003) and Rai (2004). The word cotton is derived from Arabic language and is pronounced as "qutun", "kutan" and "qutan". Cotton in today's fast moving world is still nature's wonder fibre providing thousands of useful products and supporting millions of job seekers as it moves from the field to fabric and is rightly considered as "White Gold", according to Mahalingam (2001) and king of textile fibres by Lyre (2000). Cotton enjoys an extremely positive image due to its naturalness and gentleness to the human skin (Shivaleela et al., 2004).

Since centuries, cotton has been used for apparel purposes because of its well known advantages like ability to take up a wide range of dyestuff, low cost production and comfort during wear. Cotton possess many useful characteristics such as comfort, it is soft and easy to handle, has good absorbency, colour retention, good strength, is machine washable and easy to sew (Johan et al., 2003).

Nakamura (2000) summarized that cotton is characterized by excellent properties like absorbency, biodegradable, breathable, non-allergic, heat resisting, high wet strength and water retaining capacity. The comfort characteristic is the outstanding one for apparel and other products. The most important property of cotton is that it regains moisture and becomes comfortable to the wearer especially in the hot climate, explain Prakash and Pardeshi (2004). More over, cotton offers excellent resistance to heat as well as dimensional stability and can stand temperature up to 175°C. It is also speaking in favour of cotton that the fibres is biodegradable (Mayekar, 2002).

All these qualities are responsible for considering cotton as the king among all natural cellulosic fibres.

The world's cotton industry today represents a multibillion dollar enterprise from the production of raw fibre to finished textile product records (Natarajan, 2004). The value of its textile sale has grown to 15 billion in 2005, from 13 billion in the previous year. The country's share of the world market is expected to double by 2010 from four percent now. India's cotton production is likely to zoom about 25 million bales in the year 2005 from an estimated 21.5 million bales with more areas under cultivation, expresses Asley (2003).

More than hundred varieties of cotton are grown commercially in different parts of India. The quality of cotton is directly related to span length and is the parameter that is commonly quoted while referring to any cotton. The basic characteristics of length and fineness of the cotton fibre are dependent on the type of seed used. However, fibre properties are also sensitive to changes in environmental conditions during the growth period. Cotton is generally classified or graded according to their length (Sidhu, 2005).

Presently cotton is classified into five staple length categories as short, medium, and medium long, long and extra long. This classification is not sufficient as other properties such as micronaire, maturity, uniformity ratio and bundle strength are equally important in deciding the spinning utility of cotton, reports Vivekanandan and Doke (2003).

## 2.3. SIGNIFICANCE OF PRETREATMENT IN PROCESSING INDUSTRIES

Textiles, in the modern world of science and technology has derived a meaning as something more than just to protect the body from the adverses of nature. Although the rising living standards and the social status have given a boost to enormous fashion trends, the basics of textile processing remain the same. Pretreatment in processing units can be categorized into dry and wet processing. Dry processing include yarn manufacturing, fabric weaving

and knitting, while wet processing includes desizing, scouring, bleaching, mercerizing and dyeing (Sarkar et al., 2004).

Textile pretreatment is a series of cleaning operations starting from the raw state of the fibre. According to Nishkan and Verma (2003) the aim is to prepare fabrics for subsequent processing operations such as dyeing, printing and finishing which is also called wet processing.

Moore and Auslees (2004) state that wet processing is a part and parcel of textiles since time immemorial and various chemicals are used in different stages of wet processing to ensure effective process conditions required. Wet processing is the most water, energy and pollution intensive process especially for natural fibres of which cotton dominates.

As far as wet processing of textile material is concerned there are certain basic chemicals essential for the process called 'common chemicals', which include acids and alkalis, oxidizing and reducing agents, electrolytes, pH, buffers and stabilizers without which no process can be performed. Water is the main ingredient for wet processing with its requirement going as high as 150 lit / kg of the textile material to be processed. The highest consumed commodity in the textile wet processing industry is water since it is the vehicle for all processes. Teli et al. (2004) and Shukla (2005) emphasize that water needs to be purified mainly for its hardness to bring within tolerance limits.

The whole operation of textile wet processing may be called as value addition process, which converts the grey textile material into aesthetically pleasing and comfortable to wear fabric (Padma et al., 2001). In the pretreatment stage, the basic minimum process is carried out using simple cleaning operations and chemicals to remove extraneous matter attached to the material and to diminish its water repellent character which is the most essential requirement to make the garment fit to wear with comfort. Hence, some of the preparatory processes like scouring, bleaching and mercerizing

are normally carried out (Shivaleela et al. 2004 and Shenai, 2004). The three categories of wet processing namely pretreatment, colouration and finishing are adopted for better and pleasing results in textile, describe Shukla (2005). It is necessary to remove the impurities for improving the efficiency of the dyeing process (Ren, 2000).

Raw cotton contains about 50 percent natural and artificial impurities such as cotton seed oil, protein, pectin matter, natural colouring matter, husks, seeds, pods, albumin and wax, which pose serious technical problems in the subsequent wet processing operations, resulting in non-uniform absorption of finishing agents and further improve the hard and feel of the goods, view Shivaleela et al. (2004).

Irrespective of the various stages of operations, every single method followed finds the basis and objective of maintenance of high quality – cost effectiveness, better performance, lower effluents, minimum input cost, minimum use of chemicals, environment friendly process and application of latest machinery which can guarantee the reproducibility of the product once approved.

As Micheal et al. (2003) emphasize the preparatory process is the first step towards quality ; the faults in pretreatment impair the reproducibility of the effect desired in subsequent stages and result in an increased amount of rejects. The process of preparing the grey cotton fabric for further finishing is called pretreatment a preparatory process (Prabu and Bharathimohan, 2003). The basis for even dyeing produced lies in the efficient preparatory process. The impurities have to be removed thoroughly and uniformly from the fabric, the whiteness must be leveled, independent of the location within the fabric. As stated by Giridev et al. (2005) the fabrics need to be prepared before dyeing, printing and finishing. Preparation consists of a series of various treatments and rinsing steps.

The finishing operations are mostly wet processes and they include several steps like desizing, scouring, bleaching, mercerizing, dyeing, softening and stabilization (Anthappan et al., 2006). Desizing plays a major and very important role in achieving a perfect fabric feel. It is a process of impregnation of the greige fabric with the desizing agents, allowing the agents to degrade or solublise sizing material and finally to wash off degradation products to make it suitable for further processing, explains Sivaramakrishnan (2005). Desizing is done with alkali detergents, solvent emulsions, dispersants and sequesterants. Before dyeing, the material must be free from impurities as far as possible. In the form of loose fibres and yarn, cellulosic textiles contain only those impurities found in the natural state (Vankar et al., 2000).

According to Nair and Bhattacharya (2003) and Sheth and Musalle (2005) scouring is a cleaning process for removing natural and acquired impurities from fibres and fabric. It is the process which aims to improve the absorbency by removing non-cellulosic natural matter such as waxes, pectin, protein, polysaccharides, inorganic and lignin containing impurities, which protect the fibre during its growth. These non-cellulosic components affect the hydrophobic properties of raw cotton (Chakrabarthi and Mehta, 2005).

In scouring, fabrics are treated with kier boiling. The kiering liquor is an alkaline solution containing caustic soda (1 to 3 per cent of fabric weight) soda ash, sodium silicate and sodium peroxide with small amounts of detergents. The boiling is carried out for several hours (2 to 12 hours) then the fabric is rinsed well with water (Sheth and Musale, 2005). Kavitha et al. (2005) state that most fabric need to be prepared before dyeing, printing and finishing. Preparation consists of a series of treatments and rinsing steps.

Desizing and scouring can be achieved in one step by single product RAN-SC-1095 (De) series with desired absorption and whiteness specifications for excellent and consistent dyeing results. Its advantages are

better desizing efficiency, better softness, better whiteness, better strength of fabric ; better colour yield and brilliancy (Jaypura et al. and Ranka 2004).

After scouring cotton materials are bleached. Shivaleela et al. (2004) and Nayak (2006) point out that the basic aim of bleaching is to decolorize the natural colour in the fabric and further whiten the material. As Prakash and Pardeshi (2006) remark, among the two methods of bleaching - oxidative and reduction bleaching, the oxidative bleaching is most frequently used for cotton. Generally sodium hypochlorite, sodium chloride and hydrogen peroxide are the agents used for bleaching. Bleaching process involve alkali boiling for saponification and emulsification of water insoluble substances like natural greases and waxes and in addition alkaline earth mineral salts are also removed. Having fabric made absorbent, it can be subjected for bleaching using eco-friendly bleaching agents such as hydrogen peroxide, since the hypochlorite bleaching is environmentally unfriendly, emphasize Prabhu and Teli (2005).

Bleaching is carried out by treating the raw cotton successively with boiling limewater, boiling caustic soda and cooled dilute bleaching powder solution with intermediate frequency with cold dilute acid and many washings. Goods which are to be dyed need not be treated with bleaching powder excepting in the case of pale and delicate shades, but the earlier operations are always necessary (National Institute of Industrial Research (NIIR), 2005) As stated by Michael et al. (2003) scouring and bleaching for light shades, scouring for dark shades scouring, bleaching and mercerizing are carried out if the traders prefer this.

Mercerizing is the treatment of cotton on special machines with caustic soda solution of high concentration, whilst at the same time keeping the material under tension. Mercerizing is a process that is not always carried out, but is performed mainly on high quality fabrics with the aim of improving the yield of dyed and printed materials, states Pardeshi et al. (2002). The aim of mercerizing is obtaining a lusture on the fabric surface, increase in weight,

dimensional stability, high strength, elongation, uniform swelling of the cellulose fibre, better dye uptake through an increase in the inner surface and thereby improve dye absorption. Mercerizing is often carried out after desizing and scouring operations or the scouring and bleaching stages, (Sharma and Gohlot, 2005).

Mercerizing process involves treatment of fabric with about 25 per cent caustic soda liquor carried out usually at room temperature for 30-60 seconds under controlled conditions especially the fabric kept under stretch followed by washing to remove caustic soda, so that the cotton cellulose swells and combines with caustic soda to form alkali cellulose and in subsequent washing it hydrolyses to give back cotton-cellulose. Best results for dyeing is obtained when the mercerized cotton is used for dyeing (Shukla, 2005).

Shukla and Maheswari (2002) are of the view that due to increased awareness of the polluting nature of the textile effluents, social pressure is increasing on the textile processing industries to use environment friendly chemicals and processing techniques. It has become necessary or mandatory to evaluate all the products and processes in terms of their impact on the environment. World over textile processing is undergoing a vast change traditional time consuming and often polluting processes are being replaced with efficient, and quick technology.

## 2.4. ROLE OF COLOUR AND DYEING IN ENHANCING THE APPEAL OF COTTON

Love for colour is a natural instinct. Colour plays an important role in human life. Colour is the spice of life. Nature is full of fascinating colours. Colour is a matter of perception and subjective interpretation, says Shah and Maheswari (2006). Colour application not only improves surface appearance of the substrate but also expresses emotions and ideas of the wearer, explains Phukan and Phukan (2004). Rani and Singh (2003) observe that colour in ancient times was considered as a spiritual necessity, of equal importance

similar to the physical need for food. So in every civilization from the very early times to the present day, the art of applying colour through dyeing has played an important part in adding beauty to the textiles. Colour has played a dominant role in the life of human beings since time immemorial. Colorants have made significant difference in one's life and have become a part of human sensation and without colour, many events would not have been possible. Teachers, chemists and research scientists have evolved sound basics for the foundation of the colourants industry. Colours energize the imagination, enliven the spirit and continue to fascinate mankind with its vibrancy and vividity. Flowers, leaves, fruits, roots, bark and every creation of nature is a vast treasure of infinite ranges of glorious colours (Paul et al., 1996).

The knowledge and use of colour began with the dawn of civilization and man utilized the colour he found on the earth. In ancient times, there were only colourants extracted from natural resources. Although some chemistry was involved, essentially the colourant itself was obtained from either a plant or an animal. It is probable that the earliest dyes were discovered by accident, by-product stains from berries, fruits or nuts used as food. Later, as these were seen to serve their purposes, blossoms, leaves, stems, roots of shrubs, bark and twig of trees were tried and found by primitive man to be used as dyestuffs, opines Kapila (1999).

The glory of textile trade lies in its colour. According to Sivaramakrishnan (2005), dyes and the choice of colour are also important when selecting fibres that will be exposed to the sunlight. Light colours tend to reflect heat whereas dark colours absorb heat. The more the fabric absorbs sunlight the more chance for the fibres to be damaged. Medium intensity colours show sun fading less quickly than bright and vivid colours. Prolonged exposure of ultra violet rays from the sun can cause a chemical change in the finish resulting in fine hairline cracks.

## 2.5. DIFFERENT TYPES OF DYES, THEIR CLASSIFICATION, CHARACTERISTICS AND EXTENT OF USE

Natural dyeing is not a new concept of Indian horizon. Tomer et al. (2004) point out that pre mordial man first learnt the use of plant as food, later started to make cloth with fibres of plant. Today, natural fibres are recognized as cotton, silk, wool, linen, hemp, jute and ramie. The art of dyeing was discovered in the Bronze age. The Indus valley civilization already knew how to dye wool and cotton, remark Sidhu et al. (2005). In ancient epics like Ramayana and Mahabharata as well as in the Vedas there are references about use of colour according to Rani and Singh (2003). Sidhu et al. (2005) revealed that the history of natural dyes is very interesting. Egyptian mummies have been found wrapped in clothes dyed with dyes from the madder plant. Alexander, the great was supposed to have deceived the Persians into thinking that his army was wounded, by sprinkling on his soldiers with a red dye, probably madder plant juice, which contains the dye alizarin.

The dark blue indigo dye has been known for over 4000 years. When Romans invaded England, they found that the ancient people called Picts who inhabited the country, tattooed and painted themselves with Indigo. A legend recorded on coins attests that Hercules, the God of strength, discovered tyrian purple, when his dog bit a snail, which stained his jaws purple.

India was once known as a leading supplier of earliest natural dyes which were used extensively for dyeing of natural fibres until the middle of nineteenth century (Rai, 2004).

The robes of Roman emperors were dyed with tyrian purple which was extracted from Mediterranean shellfish. Yellow and red dyes were obtained from certain thistles. American Indians used various dyes from Western desert plants. In Mexico, scarlet dye, cochineal was obtained from dried insects. Insect dye include cochineal, kermes and lac red dye but in India only

lac red dye is obtained from Laccijerbacca / kerria lacca, remark Alikhan et al. (2005).

The history of natural dyes is more than 4000 years old. Till 1856 all dyes were extracted from varieties of plants as well as from a few animal sources. The use of dyestuffs antedates the beginning of any written history of man. In early times the plant world served as the principle source for the dyestuffs by which man obtained colour. The part of the plant used varied widely : roots, stalks, foliage, bark, berries and seeds were employed to varying extents according to Suneetha and Mahale (2003). Agarwal et al. (2004) and Paul et al. (2003) define the term 'natural dye' as comprising of all the dyes derived from plants, insects and minerals.

Renewable resources like plants, animals and minerals provided a medium of colouring cloth. Bansal and Sood (2004) view that due to many properties of natural dyes such as renewable resources, no health hazards, no or mild chemical reactions and no disposal problems, the natural dyes are on a comeback stage. According to Ghuznavi (2002) and Paige (2002) until the later half of the $19^{th}$ century, almost all the dyes were vegetable or animal in origin. Most of the dyes are not substantive, but must be used in conjunction with mordants. Dyeing with natural dyestuff is a traditional craft of India. Natural dyes are associated with our ancient culture and heritage. The traditional Kalamkari and Rajasthani prints, Bandhani are all arts which used natural dyes. To design clothes to give an aesthetic appeal and traditional look, as well as to venture into the latest life styles, natural dyes are required. In textiles, natural dyes can be used in apparels as it produces colours that are gentle, soft and substile, views Jaham et al. (2004).

Inspite of the natural dyes being non-pollutant, non-allergic, shade rich and warm, it lost out to synthetic dyes owing to lack of standardization and uniformity and consistency from one batch to another. The discovery of synthesizing petroleum products spelt the death knell of the indigenous industry and use of naturally occurring colouring matters became a thing of

the past. Nowadays most of the colours used in commercial textile dyeing are synthetic. They are synthesized by various means from by- products of fossil fuels – aniline and other aromatic derivatives, state Stoker (2005).

In 1771 Woulfe prepared picric acid by the action of nitric acid on indigo and showed that it dyed silk in bright yellow shades. Laurent in 1842 converted phenol into picric acid and Perkin in 1856 discovered Mauve, the first synthetic dye to be manufactured and used for practical dyeing. Faraday discovered benzene in 1825 and Hofmann isolated benzene from coal tar in 1845, and by 1869 Kekule established the structure of benzene. After the accidental invention of synthetic dye by Perkin in 1856, with the advent of coal tar dyes, the use of natural dyes receded. Today practically all dyes are synthetic. They are prepared from aromatic compounds, for which, the only available source is coal tar. Hence it is named as coal tar dyes. It paved the way for the synthetic dyes and today we have bewildering number and variety of synthetic dyes.

Synthetic dyes are classified as direct or substantive dyes, mordant dyes and chrome dyes, azoic dyes, sulphur dyes, vat dyes, disperse dyes, fibre reactive dyes, oil and spirit soluble dyes, fluorescent brightening and optical whitening agents, food, drug and cosmetic colour, cellulose acetate dyes, acetate rayon dyes and nylon dyes (www. dyesonline.net, 2006).

The discovery of synthetic dyes has completely changed the process of dyeing. The use of natural dyes diminished with increase in production of synthetic dyes. The gradual awareness about the hazardous effects of synthetic dyes on human health and environment has revived the interest in the eco-friendly natural dyes, view Rani and Singh (2003).

The application of the new synthetic dyes drove the art and craft of the natural dyes into oblivion. The unbridled use of synthetic dyes and the non-treat of effluents contained in the waste water of the dyeing process had

led to horrendous results, explain Phukan and Phukan (2004) and Singh and Tomer (2004).

During the last 10 years, realizing the importance of natural dyes there has been an increase in the production and application of natural dyes by the carpet, apparel and home textiles industry in India according to Gulrajani et al. (2001). India has a very well developed herbal cosmetics and Ayurvedic medicine production base. Many of the raw materials, which go in these ayurvedic formulation also, act as the source for natural dyes. Hence there is no problem of availability of raw materials for the natural dyes in India.

As Stoker (2005) remarks changes in legislation and a growing demand from consumers and manufacturers for naturally derived products from renewable resources have led to a revived interest in the production of chemicals from plants. Inspite of a few drawbacks the awareness and demand for natural dyes are increasing (Kumar et al., 2003).

Alps Industries (1999) and Mishra (1999) express that natural dyes are water extracted without using any solvents from 100 per cent natural sources like botanical parts, minerals and insect secretions. The vegetable dyes are obtained by extracting the colouring components present in plant sources like leaves, seeds, flowers, fruit rind, tree bark and root, quote Dayal and Dobhal (1994).

The natural dyes are in purified form and can be applied for fibre, hank and fabric dyeing. It is safe and as there is use of chemistry with natural dyes, they are eco-friendly, non-toxic and non-hazardous. They perpetuate ancient tradition and do not disturb our ecological balance, soft in colour, cool to eyes and good to skin, opines Deo and Paul (2003). Extracts of natural dyes like turmeric, *aloe vera*, neem and henna could be used for anti microbial, anti perspiration and odour free finishings.

Traditionally natural dyeing has been a labour- intensive four step process : harvesting the dyestuff, extracting the dye, preparing the goods and dyeing the fabric by immersing it in the dye bath. Sharma et al. (2007) views that the goal with immersion dyeing usually is uniform colour all-over that is fast to washing, sunlight and other environmental insults. The result of immersion dyeing are reasonably predictable based on the dyer's previous experience or information and illustrations in the natural dye literature.

Natural dyes are eco-friendly which means they do not create any environmental problem at the stage of production or use and maintain ecological balance. The popularity of natural dyes and dyeing is also on the ascent keeping with the current trends towards environmental friendly or "Green" processing of fibre to the fabric, remark Sarkar et al. (2004).

## 2.6. DIFFERENT TYPES OF MORDANTS AND MORDANTING TECHNIQUES

Natural dyes are known for their beautiful and multi-hued shades. However they have limited use in cotton dyeing, as it does not readily absorb the dye (Janhom et al., 2004). As Alikhan (2005) describe that the natural dyes require chemical in the form of metal salts to produce an affinity between the fibres and the pigments and these chemicals are known as "mordants". Dyeing with natural dyes is accomplished by the use of mordants, view Gill and Singh (2005). Sujatha et al. (2002) point out that mordants are the chemicals that bite the surface of the fibre, so that the dye sinks in. It forms the complex with the dye, that is insoluable in water and thus gives fast colour, explain Paul et al. (2003). There are three types of mordants-metal salts or metallic mordants, tannic acid and oil mordant. Not all dyes need mordants to help them adhere to fabric. If they do not need mordants, they are called substantive dyes. If they do need a mordant they are called adjective dyes (Phukan and Phukan, 2003 and Sengupta, 2004).

Agarwal and Singh (2003) point out that wood ash may be used as an alkali mordant, and acids obtained from acidic fruits or rhubarb leaves may be used as mordants. Ramakrishnan (1999) and Mishra (2000) suggest that most of the dyes are not substantive, but have to be used in conjunction with mordants like wood ash, urine, saliva, egg albumin, tannin or metallic salts to mention some. As pointed out by Vankar et al. (2000) the idea of using of bio mordants was to reduce the usage of chemicals and to see the effect of dye uptake as well as for the reconstruction and revival of traditional dyeing techniques, and to achieve eco-friendliness.

Nowadays use of chemical mordants such as alum, copper sulphate, iron or chrome are used along with most of the natural dyes (Bhattacharya, 2002). As mentioned by Pal and Rao (2003) the most commonly used mordants are alum and aluminium sulphate and is considered as the best mordants in dyeing with natural dyes as their environmental toxicity is low as compared to the other metallic mordants. Baird (2000) points out that alum is simply potassium aluminium sulphate or a salt in chemical terms.

Johan et al. (2004) and Deo and Paul (2003) inform that an almost complete range of soft, lustrous, gentle, excellent and subtle colours can be obtained by appropriate combination of various natural dyes and mordants. Alum is usually used with cream of tartar and helps to obtain evenness and bright colours. Iron or copper darkens colours and bringing out green shades, tin, usually used with cream of tartar, blooms or brightens colours, especially red, orange, yellow and blue, (www.fabrics.net). Ferrous sulphate produces a grey to chocolate brown colour range while copper sulphate gives pale brown to henna colour with different mordanting techniques (Patel et al., 2003). Currently, most dyeing processes use metallic mordants not only improves the colour yield but also provide a wide variety of shades with different hues. Unfortunately many of the metallic mordants are toxic and have serious detrimental effects on the environment. Hence, a new type of mordant is required. The main problem with natural dyeing is that, whilst the natural dyes

are themselves harmless, the mordants are generally not eco-friendly. In order to develop a totally eco-friendly natural dyeing process, it is necessary to replace the metallic mordants with eco-friendly mordants, remark Deo and Paul (2003).

Technological upgradation is the need of the hour in order to revive the dyeing process with natural dyes and standardize some newer sources of natural dyes and mordants and generate new information (Bellow and Abdul, 2003). Commercialization of natural dyes can be done successfully by a systematic and scientific approach to extraction, purification and use of natural dyes. Teli et al. (2004) emphasize that optimization of extraction conditions is a must to minimize the investment cost and to avoid discrepancy in the dyed shade quality.

Mahale et al. (2003) report that Alum and Harda are most eco-friendly mordants. Harda one of the natural mordant is the gift of nature. It contains sufficient tannic acid which remains with peels of the fruits. One can obtain pure tannic acid which can be used for producing pure black shade. The black shade is due to formation of tannate of iron according to Shankar and Vankar (2003).

Good sources of tannins include tea, oakgalls, persimmons, rinds of pomegranate fruits and myrobalan powder. It is probably best to treat the fabric with the tannins first and then with the dye solution (Devi et al., 2002).

Metallic mordants are the naturally occurring metal salts of aluminium, chromium, iron, copper and tin. Some of the commonly used mordants are alum, potassium dichromate, ferrous sulphate, copper sulphate, stannous chloride and stannic chloride (Patil, 2003).

Tannins and tannic acid are primarily used in the preservation of leather. They are also used in glues, stones and mordants, vegetable tannins are bitter astringent substances found in plants often occurring as excretion of the bark and other parts. For tanning purposes, the extractions are either

employed directly or used in a concentrated form by extractions of the tanning substances. Among the tannins, myrobalan and sumach are most important.

Oil mordants are mainly used in the dyeing of Turkey red colour from madder. The main functions of the oil mordant is to form a complex when alum is used as the main mordant. Treatment of oil with sulphuric acid produces sulphonated oil, which possesses better binding capacity than the natural oils due to the presence of the sulphonic acid. The band metal forms a complex with the mordant to give Turkey red colour of superior fastness and hue. The oil contains fatty acids such as palmitic, stearic, oleic and their glycerides, the COOH groups of fatty acids reacts with metal salts and convert in to COOM, where M denotes the metal sulphonated oils have better metal binding capacity than the natural oil, explains Singh (2000).

In dyeing with natural dyes mordants are almost indispensable to give substantivity. Mordants can be applied to the fibre before dyeing, at the time of dyeing, or after dyeing (Vankar et al., 2001). Earth hues recommend pre-mordanting as they get better colours than when mordanting at the same time of dyeing, states Bains et al. (2003).

Gupta (1999) points out that the fastness of a mordant dye depends on the mordant and mordanting method because different metal dyed complexes are formed which may differ in their stability to light and also because the metals may have a positive or negative effect on the photochemical degradation of dye.

Natural dyes are classified in various ways. The earliest classification was according to alphabetical order and later the classification was based on chemical structure in the colour index. It is classified according to chemical constitutions and major application classes. Within application class, the dyes are arranged according to hue. Chemically, these dyes have different groups such as poly-methine, ketone, amine, quinines, anthraquinoids, flavines, indigoids and chlorophenyls. However, natural colouring matters are broadly

classified into three categories namely i) vegetable origin ii) animal origin and iii) mineral origin (Sharma, 1996).

**i. Dyes from vegetable origin**

Natural dyes of the plant origin are derived from root, leaf, bark, trunk or fruit of plants. These are madder, henna, turmeric, kilmora, onion, shyama, kaiphal, chin, red sandal wood, cutch, semul, walnut, oak, teak, nargis, kamala and pomegranate.

**ii. Dyes from animal origin**

Lac, cochineal and kermes has been the principal dye yielding insects. The other animal dyes are squid sepia and tyrian purple obtained from species of fish and small insects.

**iii. Dyes from mineral origin**

Various inorganic metal salts and metal oxides are available for use. According to Singh (2000) and Ansari and Thakur (2000) natural dyes are classified into three groups namely

- affinity based, application based, structure based

Natural dyes have several advantages over synthetic dyes.

According to Shukla and Patil (2006) and Singh and Parmer (2000), the natural dyes have the following advantages :

- ❖ Natural renewable sources
- ❖ Soft in colour, cool to eyes, good to skin
- ❖ Biologically degradable
- ❖ No health hazards, sometimes they act as health cure
- ❖ They have lower toxicity, are non-allergic and non-carcinogenic
- ❖ Good resistance to moth invasion, anti-allergents, safe for body contact
- ❖ It saves energy because the raw materials are not from petroleum products

Natural dyes also have some limitations for commercial use, according to Mishra (2000).

They are

- Allow only natural fibres to be dyed
- Non-standardized, non-reproducibility of shades due to differences in maturity and climatic condition.
- Natural resources are not available in all the countries
- Poor fastness properties
- The yield of natural dyes is so small that it is very difficult to obtain adequate supplies to meet today's requirement of dyestuff consumption

Various reasons for declining the use of natural dyes are as follows:

- Discovery of synthetic dyes
- Poor information, dissemination and technology transfer
- Poor scientific inputs (Nalankilli,1997)

## 2.7. ENVIRONMENTAL POLLUTION

Ecological balance of nature is threatened by increasing environmental pollution due to rapid industrialization in the world. Textile industry is the major polluters by discharging dyes and chemicals, waste liquor into ground and to river water. A large number of chemicals of diverse nature are involved in the process and thus the effluents pose a definite environmental threat (Prabhu and Arputharaj, 2003). Textile Industry being one of the largest industries, has gained attention towards pollution of water and air caused by textile mills and allied industries like dye and dyestuff industries.

Environment pollution is classified into various groups, the pollution of air is termed as the atmospheric pollution, the pollution of hydrosphere or water is termed as water pollution, while pollution due to disposal of wastewater is termed as industrial effluent pollution. Environmental pollution causes health problems by affecting human health and lives, economical

problems by affecting human prosperity and materials, ecological problems by disturbing a balanced eco-system, interfering with the conservation of natural resources and threatening the mere existence of some species and aesthetic problems by generally affecting human senses (Paul et al., 2003). The chemicals form an integral part of the various wet processes to maintain the desired conditions that are mandatory for carrying out the dyeing processes. Basic chemicals like alkalis, organic and inorganic acids, solvents, soaps oxidizing and reducing agents are the most essential requirements for carrying out the specific wet processing stages which may not be eco-friendly, say Vaishnav and Joshi (2000). Their eco-friendliness can not be questioned, as only possibility being substitution-using hydrogen peroxide as an oxidizing agent instead of hazardous chlorine-containing bleaching powders, suggest Prabhu and Teli (2005).

The present processing methods are causing enormous damage by the way of water pollution by releasing toxic chemicals, non-biodegradable dyes, total dissolved solids and sludge from effluent plants, warns Mathiazhagan (2004). The severity of the pollution created during wet processes that textile material undergoes depend on the impurities of the input materials. Only in-depth knowledge of all stages of textile manufacture can give better understanding of the over all pollution load and methods to minimize it (Lal, 2003).

Textile wet processes use large amounts of water, mainly because of washing operations say Kavitha et al. (2005) and Storti et al. (2005). Therefore, processing wastewater have large quantities of chemicals.

The wastewater has serious negative impact not only on underground and surface water bodies and the land in the surrounding area, but also had an adverse effect on the aquatic ecological systems, opine Alikhan et al. (2005). Due to usage of dyes and chemicals, effluents are dark in colour, which increases the turbidity of water body. This inturn hampers the

photosynthesis reaction carried out by the same microorganism in the biological treatment of the effluent, remark Paul (2005).

Textile wastewater contains substantial pollution loads in terms of Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and heavy metals. The values for these parameters are very high as compared to the values set up by the environmental quality standards. The characteristics of textile wastewater is a pre requisite for the selection of various treatment options. The concept of increasing quality control is deep rooted and has become mandate for all industries, views Shukla (2005).

Usually each of these wastewater streams from the various departments merge into one common stream called composite effluent which is given necessary treatment before being discharged into the receiving body. The nature and chemical composition of textile wastewater will vary depending on the process carried out in the textile process houses.

Recent findings on harmful effects of synthetic dyes on environment and human beings made the world realize the need to develop eco-friendly, safe dyes that may be used for textiles suggest Sharma and Gohlot (2005).

However due to increased awareness of the polluting nature of the textile effluent, social pressure is increasing in the textile processing industries to use environmental friendly chemicals and processing techniques. It has become mandatory for the textile industries to evaluate all the products and process in terms of their impact on the environment. The very first approach is to reduce the pollution load by using different techniques like minimize / reuse the raw materials, adopt eco-friendly dyes, chemicals and processes, if pollution is unavoidable, then eliminate/reduce its after effects, state textile experts, Prabhu and Arputharaj (2003). In the processing of textiles, environmental issues had been over looked by the textile processors all these years, explains Nishkam and Verma (2003).

The safest may be the use of eco-friendly natural dyes. Thus, it is of immense importance to find the additional sources of natural dyes which are available in plenty, express Park et al. (2004).

According to Phukan and Phukan (2004), the growing eco-concern all over the world has once again propelled the revival of natural dyes with the aim to reduce effluent problem on one hand and the carcinogenic effects of synthetic dyes on the other.

## 2.8. NEED FOR IMPROVING THE EFFICIENCY OF NATURAL DYES

Since advent of synthetic dyes textile dyeing units are making increased use of chemicals for getting bright and colourful shades on different textile substrate, these chemicals are now identified as harmful for human health in addition to causing damage to the environment. Hence emphasis is given for dyeing the fabrics using products and application techniques with minimum damage to human health and ecology. Hence there is need to utilize potential natural dye sources especially for commercialization for textile colouration in textile dyeing units and industries (Velantina et al., 2006).

The environmental problems are closely associated with the discharge of effluents from the processing industries. The processing is a non-consumptive process, which means that virtually all used water in the process is discharged. The discharged effluents contain a portion of variety of dyes and chemicals and their derivatives used in the processing, which lead to environmental damage on ground water, soil and the natural eco-system. In textile processing industry, the important aspects to be considered are minimizing the pollution below specified limits minimizing the usage of harmful chemicals below specified limits and minimizing the discharge of waste water volume to possible extent, through recycling the effluent (Prabhu and Bharathimohan, 2003).

In addition to health hazards caused by dust, textile workers who work with synthetic dyes develop skin allergies or rashes. Washing agents such as

formaldehyde used can cause allergic reactions that affect the respiratory system (Pardeshi and Shukla, 2005).

Thus ecological balance of nature is threatened by increasing environmental pollution due to rapid industrialization in the world (Sandeep, 2006). The present textile wet processing methods are causing enormous damage by the way of large quantities of wastewater, most of which is discharged in the form of effluents into land and this wastewater contains toxic chemicals, non-biodegradable dyes, total dissolved solids and sludge causing huge damage and change in the soil composition. These harmful pollutants if present in appreciable amount not only will make the water unfit for use, but will also destroy the vegetation and crops according to Jaya Paliwal (2001).

The protection of environment has become a challenge and reduction of synthetic dye effluent has become a must because of their carcinogenic nature and some of the dyestuffs are hazardous to the skin health also. Effluents of synthetic dyes have caused great danger to mother earth making it unfit for cultivation and curtailing its fertility (Sreerangarajan, 1999).

Since April (1996) direct, acid, basic and disperse dyes among other dyes consisting of azo group have come under the banned products, these dyes under suitable conditions of reductive atmosphere release amines which are either carcinogenic or allergic. Hence the need emerges for identifying substitute safe dyes (Asley, 2003). Not all the materials can be substituted with eco-friendly ones, however effects must be made in that direction. Many chemicals have been black listed as toxic, carcinogenic to human beings and hence if it is not possible to eliminate them for want of a particular effect, they need to be substituted with non-polluting or less polluting ones which will bring that effect (Shukla, 2005).

Most of the dyes based on objectionable banned amines are already taken out from the market and hence the use of eco-friendly dyes have

become obvious expectations. In this context, the use of natural dyes are increasingly becoming popular. Even though there is variation in colour content of raw materials with tedious extraction process and requirement of use of metallic mordants still textiles can definitely be dyed with natural dyes, if some of these drawbacks are overcome through research (Pardeshi et al., 2002). Thus the need to realize the importance and research on the technology of natural dyes has become the need of the hour (Panchal et al., 2005). Increased concern and awareness towards maintenance of ecological balance has led to the revival of natural colourants. Technology up gradation is the need of the hour in order to revive the dyeing art of natural dyeing. Mounting public awareness about environmental issues over the past decade, scientists have started exploring the use of natural colourants as possible means of producing an ecologically sound product and appealing to the green-minded consumers (Sood and Bansal, 2002).

The increasing awareness at present both nationally and internationally of pollution, ecology and environment are associated with synthesis, processing and use of natural dyes as pointed out by Singh and Agarwal (2003). Today in the world of growing environmental consciousness, natural colourants have attracted the attention of everyone, considering the point of view of safety of health and a growing demand from consumers and manufacturers for naturally derived products, from renewable resources (Stoker, 2005).

Recently extensive researches are being carried out in the world on the application of natural dyes to textile substrate as textile colourants. Most of the dyes are well absorbed on the substrate during dyeing process (Patel et al., 2005). The use of various metallic salts as mordants not only improves the colour yield but also provide a wide variety of shades with different hues (Patel et al., 2003). The idea of using bio mordants is to reduce the usage of chemicals and to see the effect of dye uptake in the case of bio mordants as well as for the reconstruction and revival of traditional dyeing techniques and for eco-friendliness (Vankar et al., 2001).