DECOLORIZATION OF DIRECT AND BASIC DYE SOLUTIONS USING RIVER SOIL

By

MALA . S

[Reg. No.09PBS05]

A DISSERTATION SUBMITTED TO THE

AVINASHILINGAM DEEMED UNIVERSITY FOR WOMEN
COIMBATORE – 641 043.

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN BIOTEXTILES

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CERTIFIED AS BONAFIED RESEARCH WORK

GKrishnabai

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OF THE DEPARTMENT

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Introduction

1. INTRODUCTION

Color is an intriguing part of the everyday lives. The various process used in the textile processing industry contributes color’s major portion to the environmental pollution. Color is also a psychologically very important factor in water pollution, states Menezes (2010). One of the main threatening problems in the industrial world facing today and applicable to dye stuff is the pollution problem. The dye stuff industrial wastes in the form of atmospheric gases and waste waters have been found to be polluting the neighboring area. Rapid industrial development and urbanization in India has resulted increasing of generation of waste water and effluent at alarming rate. Textile industry is the second largest industry in the world only next to agriculture, express Rajasekar and Gurusamy (2010).

Wet processing of textile industry gives valuable effects to the clothing sector but in the same time waste effluents from that industry pollute the environment in many ways. Most of the textile effluent treatment plants are discharging their sludge to the environment without consideration of possible side effects. Since this kind of sludge is generally considered as pollutant, the sludge treatment of textile industry seems to be an essential task. Commercially, textile waste generation is influenced by the production of textile goods, higher the production, the greater the amount of waste. The management of waste is a formidable problem. Textile waste effluents are one of the waste waters that are very difficult to treat satisfactorily because they are highly variable in composition and contain several different recalcitrant compounds. Waste waters that are generated at various stages of the dyeing process differ in compositions and temperature. Wet processing of textile industry gives valuable effects to the clothing sector but in the same time waste effluents from that industry pollute the environment in many ways.

Textile industry effluents exhibit large amounts of dye chemicals, which create severe water pollution. It is therefore important to reduce the dye concentration in the wastewater before discharging into the environment. The textile wastewater, which includes high color, high suspended solids, and dissolved organics, comes from dye houses. On a general fact, higher the intensity of the color, higher is the toxicity of the effluent and in turn greater the harm to the ecology. Such colored industrial effluents from the dyeing industries represent major environmental problems. The textile industry wastewater is rated as the most polluting among all industrial sectors in terms of both volume and composition of the effluents. The color in these wastewaters is due to synthetic dyes left unused due to industrial inefficiencies. Presently over 10,000 different dyes and pigments are used in dyeing and printing industries all over the world. The total world colorant production is estimated to be 800,000 tons per year and at least 10-15% of the used dyestuff enters the environment through wastes.

Control of pollution is one of the prime concerns of society today. With economic constraints on pollution control process, affordable and effective methods have become a necessity. Untreated or partially treated waste waters and industrial effluent discharges into natural ecosystems pose a serious problem to the ecosystem and the life forms. Among the various pollutants present in industrial wastewaters, color is considered to be a ‘visible pollutant’ and is most difficult to remove from wastewater, state Raghuvanshi *et al* (2004). Dyes vary in chemical composition, but share common features. They are highly stable to external agents such as chemical compounds and light. Dyes tinctorial value is high: less than one ppm of dye concentration produces obvious coloration. This makes it difficult to remove color from the wastewater. About 100,000 commercial dyes are manufactured including several varieties of dyes such as acidic, basic, reactive, azo, diazo, antharquinone based meta complex dyes. Over 10,000 dyes within an annual production of over 7×10^5 metric tons are commercially available. Due to inefficiencies of the dyeing process in textile industry, 10-15% of the dyes are lost in the effluents. It is estimated that 2, 80,000 tons of textile dyes are discharged in textile wastewater every year worldwide. The majorities of these dyes are toxic, mutagenic, carcinogenic and possess a potential health hazard to all forms of life. The strong color of discharged dyes even at very small concentrations has a huge impact on the aquatic environment caused by its turbidity and high pollution strength; in addition toxic degradation products can also be formed.

Physical and chemical methods such as adsorption, coagulation – flocculation, oxidation, filtration and electrochemical methods may be used for color removal from waste water. These methods are quite expensive and have operational problems. All these methods have different decolorization capacities, capital costs and operating speed. Among these treatment technologies, adsorption is the most promising option for the removal of non-biodegradable organics from aqueous effluents, activated carbon being the most common adsorbent for this process due to its effectiveness and versatility. But both chemical and thermal regeneration of used carbon is expensive, impractical on large scale and produces additional effluent and results in considerable loss of the adsorbent, reports Aksu (2005). These physical and chemical methods have inherent drawbacks as they generate a significant amount of sludge or cause secondary pollution due to the formation of sludge or hazardous by-products.

“Take care of the land and the land will take care of you”. “Soil conservation is not just an incidental bit of the mechanics of farming; it becomes part and parcel of the whole business of making a living from the land, and is th only way by which we may leave permanently productive land for a permanent agriculture to support a permanent nation”.Soil is cheaper than activated carbons and has gained attention as potential efficient adsorbents, because they are lamellar silicate minerals with structures providing high specific surface areas and are able to adsorb cations on particle external sites and in interlayer positions. The chemical composition and in interlayer positions. The chemical composition and the hydration state of the soil play a major role in this adsorption. Different types of water soluble dyes can be effectively adsorbed on soil minerals. The use of soil in wastewater treatment has received increasing attention and currently offers a very attractive method for pollution remediation. Besides it is plentiful and inexpensive, emphasizes Raghavacharya (1997).

Considering these environment friendly technology utilizing soil for the decolorization of the direct and basic dye effluent, an attempt has been made to experiment the decolorization of direct and basic dye solutions using river soil.

The objectives of the study are:

- To assess the characteristics and pollution load of selected direct and basic dye solutions.
- To decolorize the selected dye solutions using river soil.
- To optimize various parameters such as dye concentration, soil concentration, time, pH and temperature on dye decolorization.
- To evaluate the effectiveness of dye treated water.
- To utilize the treated water for dyeing and irrigation purpose.
- To evaluate the growth of plants by biometric and biochemical analysis.
- To evaluate the dyed sample.

Review of literature

2. REVIEW OF LITERATURE

A brief review of literature pertaining to the study **"Decolorization of Direct and Basic Dye Solutions Using River Soil"** is presented under the following headings.

2.1 Dye

2.2 Decolorization

2.3. Soil

2.4 Direct Dye

2.5 Basic Dye

2.6 Recycling of Treated Water for Irrigation

2.7 Water in the Textile Industry

2.8 Cotton

2.1 DYE

A dye is usually a colored organic compound or mixture that may be used for imparting color to the substrate such as cloth, paper and plastic. Today most of the available dyes are synthetic dyes prepared from aromatic compounds which are obtained from coal tar or petroleum, remarks Barker (2007). The molecules of organic compounds called dyes are responsible for the color of dyed and printed textile fibre materials. The chromophores give the dye molecule its particular color, while the auxochromes intensify the hue of the dye molecules color, state Gohl and Vilensky (1999). Synthetic dyes are first derived from coal tar in 1856. It is presumed that the art of dyeing first came to be known 3000 years ago, report Gupta et al (2008). Dye molecules are complex aromatic structures with extended π electron systems, polar substituent and water solubilising groups, emphasizes Johnson (1995).

The requisites of a true dye are, it must have a suitable color, it must have an attractive color, it must be able to attach itself to material from solution or to be capable for fixed on it, defines Smith (2006). The art of dyeing has been changing and developing so much from century to century, says Pellew (1998).Luster and color are two associated phenomena which demand particular attention from textile field due to their prominent influence on the appearance of fabrics, suggests Grosicki (2004). The color of the dyed material should not be affected on prolonged exposure to light, water and soap, ie, the dye must have fastness properties, determines Yadav (2008).The proper selection of dyes is of the greatest importance to the production of satisfactory results, (NIIR).

2.1.1 Types of Dyes

There are two major sources of dyes. They are Natural dyes and Synthetic dyes. Natural dyes are those which are obtained from nature without chemical processing, that is, they can be sorted from plants(indigo), animals (cochineal)and minerals (oches), states Takhur (2006). Natural dyes can be applied on all kinds of both synthetic and natural yarns, fabrics and knitted fabrics, remark Tomer and Singh (2004).Natural dyes comprise of many chemical classes such as erithocyanins, flavanoids, quinines, dihydrophyrane, indigoids, carotenoids and chlorophylls, quotes Barker (2007). Synthetic dyes are aromatic molecular structural compounds. The classification of synthetic dyes are based on the chemical construction of the dye molecule and the method of application of dye, say Gohl and Vilensky (1999). Synthetic dyes are also classified according to chemical structure. They are water soluble, solvent soluble, insoluble in water, (NIIR).

Direct dyes are known as substantive dyes and can be applied to the fiber directly from an aqueous solution. These dyes cover the entire shade gamut and easy to apply, expresses Mahadevan (2008). Acid dyes are sodium salts of sulphonic acid and nitro phenol and can easily dye wool and silk. These dyes give very bright hues and have a wide range of fastness properties from very good to very poor, remarks Mangal (2010).Basic dye is a type of dye that colors wool and silk without a mordant. They are also called cationic dyes, because in solution the basic dye molecule ionizes, causing its colored component to become a cation. They generally give intense and brilliant shades but have poor light fastness, states Pellew (2007). Mordant dyes are also known as adjective dyes and do not dye a fiber directly. They require a mordant, which can be metal hydroxide and tannic acid, emphasize Collier and Tortora (2001).

Vat dye cannot be applied directly since they are insoluble in water. These dyes are applied in their reduced forms. Vat dyes are quite fast to washing, light and bleaching. Vat dye gives excellent fastness and is generally used on cotton fabrics, exhorts Corbman (2000). Disperse dyes are non- ionic dyes having low molecular weight and are used for dyeing fibers like nylon etc. these are a class of water insoluble dyes originally introduced for dyeing cellulose acetate and usually applied from fine aqueous dispersion, quotes Conway (1997). Ingrain dyes are produced in the fiber itself during the process of dyeing, and are extremely fast to light and washing, remarks Vidyasagar (1998). Azoic dyes are produced inside the textile fiber by azo coupling. The dye is firmly occluded and is fast to washing. The major application of azoic dyes is in the dyeing and printing of cotton, giving shades of a high standard of fastness to light and wet processing, state Shenai and Saraf (1997).

Oxidation dyes can be produced in textile fibers by oxidation of a colorless compound. The appearance and fastness of the dyeing can be varied over a wide range by the choice of oxidant, conditions, a catalyst, expresses Wells (2000). Sulphur dyes are insoluble dyes. When reduced with sodium sulphide, they become soluble and show affinity for cellulose. These dyes are cheap and give dyeing of good fastness to washing. However, their brightness and fastness to bleaching are generally inferior, determines Raul (2005). Reactive dyes are a relatively new class of dyes and form covalent bonds with fibers possessing hydroxyl or amino groups. Reactive dyes provide excellent fastness to washing as the dye becomes a part of the fiber, quotes Thomas (2006). Solvent dyes contain no sulpho or other water solubilizing groups. These are soluble in organic solvents, the nature of which changes according to application, insists Yadav (2008).

2.2 DECOLORIZATION

Decolorization is the removal of color from the industrial effluents. Colored effluents are objectionable on aesthetic ground for many uses. The presence of dye on natural water systems inhibits sunlight diffusion into water. In view of this several systems have been developed for removal of color from colored waste water effluents, states Sekar (2008).

2.2.1 Methods of Decolorization

The decolorization of waste water may be classified into three main categories namely physical methods, chemical methods and biological methods.

2.2.1.1`PHYSICAL METHODS

Physical methods of removal of dyes from effluent through adsorption are a well known method. Adsorption is a rapid phenomenon of passive sequestration and separation of adsorbate from an aqueous or gaseous phase on to a solid phase, state Vinod and Puttaswamy (2010). The adsorption technique is superior to other techniques with regard to simplicity of design, initial cost, ease of operation and insensitivity to toxic substances, report identification of a potential dye sorbent must be in good agreement with its dye binding capacity, its regeneration properties and its requirements and limitations with respect to environmental conditions, report Lee et al (2006) and Espantalion *et al* (2003).)Decolorization is a result of two mechanisms, adsorption and ion exchange, and is influenced by many physic chemical factors such as dye / sorbent interaction , sorbent surface area , particle size, temperature , pH and contact time, emphasizes Hazel (1995). The most commonly used adsorbents are activated carbon, peat, fly ash and coal, wood chips and silica gel, quotes Palit (2010).

Treatment with activated carbon seems to be a promising method due to its lower cost and simplicity in operation. Adsorption on activated carbon is one of the most efficient treatment methods available for the removal of organic matter and some inorganic materials from the waste water, states Manivasakam (1995). Activated carbon is the original absorbent used to absorb dye molecule and remove color. The activated carbon can be used in granulated (GAC) and powdered (PAC) form, remark Parvathy *et al* (2010).The cellulose structure of peat makes it an ideal choice as an adsorbent. Peat is a low grade carbonaceous fuel containing lignin, cellulose and humic acids as its major constituents. Peat requires no activation unlike activated carbon, and also cost much less, expresses Souther (1995).

Wood chips show a good adsorption capacity for acid dyes, due to their hardness. They are not as good as other available sorbents and require a longer contact time, states Thakur (2006).Silica is used as an adsorbent mainly in granular form. Silica is an effective material for removing basic dye, although side reactions such as air binding, air fouling with particulate matter prevent it from being used commercially, reports Gasey (1997).A high fly ash concentration increases adsorption rates of the mixture by increasing the surface area available for adsorption, quote Mohan *et al* (2002) and Ahmad *et al* (1995).

2.2.1.1.1 Membrane Technology

Membranes are the best available technology for water and waste water treatment. This method has the ability to clarify concentrate and most importantly to separate dye continuously from effluent. Different types of membranes are available which are classified according to the size of the particle that can passes through the pores. The different types of membrane technologies are, Ultra Filtration, Nano Filtration, Reverse Osmosis and Electro Dialysis, reports Sridhar (2010)

Ultra Filtration is a very important technology in waste water treatment. It is mainly used as a pretreatment of nano filtration and reverse osmosis. But ultra filtration is of no use in color removal as the membrane pore size is too large to prevent dye molecules passing through. Nano filtration has a pore size much smaller than ultra filtration and hence can reject many color causing elements. Nano filtration can very effectively separate dyes and concentrate them too, says Sekar (2008).

Reverse osmosis also known as hyper filtration, is a very fine filtration method. The most common use of reverse osmosis is in purifying water. The advantages of reverse osmosis are both inorganic and organic pollutants can be removed simultaneously by reverse osmosis membrane process. Reverse osmosis membrane systems often require less energy, lower capital and operating costs than many conventional treatment systems, (KYT Group, 2004). Electro dialysis is an electro membrane process in which the ions are transported through a membrane from one solution to another under the influence of an electrical potential. Electro dialysis can be utilized to perform several types of separations like separation and concentration of salts, acids and bases from aqueous solutions and heavy metal recovery, remarks Menezens (2010).

2.2.1.1.2 Ion Exchange

Ion exchange technique is used for removal of heavy metal ions from waste water. Both cation and anion dyes can be removed from dye containing effluents in this way. Advantages of this method include no loss of adsorbent on regeneration, reclamation of solvent after use and the removal of soluble dyes. A major disadvantage is the cost, quotes Manahan (2000).

2.2.1.1.3 Electro Kinetic Coagulation

Electro kinetic coagulation is a economically feasible method of dye removal. It involves the addition of ferrous sulphate and ferric chloride, allowing excellent removal of direct dyes from waste water, indicate Lee *et al* (2006).

2.2.1.2 Chemical Methods

In this method chemicals are used for the degradation of dye molecules. Chemical methods enable the destruction or decomposition of dye molecules, and such approaches use various agents, such as ozone and. hydrogen peroxide, states Metcalf (2003).

Oxidation method is the most commonly used method of decolorization by chemical means, which is mainly due to its simplicity of application. The main oxidizing agent is usually hydrogen peroxide. In oxidation process, the chromophore is destroyed or converted into biodegradable form such as carbon dioxide, water, nitrogen and acids, by attacking weak bonds in the dye molecules with suitable oxidizing agents, remark Shukla (2006) and Boon *et al* (2000).

Ozone is the most powerful oxidizing agent capable of oxidizing most chemical pollutants. The use of ozone was first pioneered in the early 1970's.Ozonation is an effective treatment method for the degradation of a wide variety of dyes in aqueous solution as ozone selectively destroys conjugated double bond associated with color. One major advantage is that ozone can be applied in its gaseous state and therefore does not increase the volume of waste water and sludge. The disadvantage of ozonation is its short life; it affects salts, pH and temperature, express Honade and Sreevasthava (2010). Ozonation has been found to be effective due to its high reactivity with many azo dyes, the lack of alteration of the reaction volume due to its gaseous state, and good color removal efficiencies, emphasize Alaton *et al* (2002). However its short life time, ineffectiveness towards dispersed dyes and those in soluble in water, low COD removal capacity, as well as the high cost of ozone, limits the practical application of this technique, report Anjaneyulu *et al* (2005).

Hydrogen peroxide partially oxidizes the dyes in waste water simultaneously increasing the amount of oxygen content of water and decreasing the COD. The disadvantage is longer reaction time and cost. Color removal is greater at high temperature, insist Salem (2001) and Badmus *et al* (2007).

Fenton's reaction is one of the advanced oxidation process that can be described as a generation of UOH radicals through catalytic decomposition of hydrogen peroxide, carried out by a transition metal such as ferrous ion. Fenton's oxidation is capable of treating both soluble dyes and insoluble dyes. The advantages of Fenton's reaction are, hydrogen peroxide is environmentally friendly, lack of toxicity and ease of removal from water, suggest Badawy *et al* (2006) and Kuo (2000).Sodium hypochlorite is a high redox potential oxidant. It requires further dechlorination of waste water to prevent toxic effects in further biological process. They, however release a lot of aromatic amines which are carcinogenic, or otherwise toxic compounds; these subsequently aggregate the problem, views Shukla (2006).

Photo chemical process degrades dye molecules to carbon dioxide and water by UV treatment, in the presence of hydrogen peroxide. The advantages of photochemical treatment of dye containing effluent are no sludge is produced and foul odors are greatly reduced, reveals Katkar and Bairgadar (2010). Electro chemical treatment of various types of dyes through electro oxidation or by electro coagulation cause decolorization leading to the formation of corresponding amines. The electro chemical reduction of dye is also possible. Although the azo dyes are readily decolorized by reduction, the resulting aromatic amines are carcinogenic, state Gode and Pehlivan (2006). Electro chemical oxidation is very effective in destroying organic compounds and producing non- hazardous products, but the high cost of the electricity required has also limited the use of this process, express Morawski *et al* (2009).

2.2.1.3 Biological Methods

Biological treatment methods are attractive, cost effective and a novel technology. The treatment of textile waste water by purely biological process may be possible even without the inclusion of other carbon sources, state Tavallali *et al* (2010). The most commonly using biological methods are activated sludge, trickling filtration and the use of agricultural solid wastes.

2.2.1.3.1 Activated Sludge

Activated sludge process is the most versatile biological oxidation method employed for the treatment of waste water containing dissolved solids, colloids and coarse solid organic matter. In the activated sludge process, textile processing waste after clarification is fed into an aeration tank where it is continuously exposed and subjected to biological degradation carried out by the microbial floc suspended in the reaction tank in to which oxygen is introduced by mechanical means. The effluent from the reaction tank is allowed to settle and a portion of the sludge is recycled to the tank itself for effective microbial population, reports Sivaramakrishnan (2010).

2.2.1.3.2 Trickling Filtration

Trickling filters are the oldest form of biological waste water treatment. They are also referred as biofilters and percolating filters. In this method, waste water after primary treatment is sprinkled over a bed of broken stones. The bacterial slimes formed on the stones oxidize the waste water during its passage. The effluent from trickling filter is allowed to settle and then discharge. The trickling filters are usually circular, quotes Purohit (2008).

2.2.1.3.3 Agricultural Solid Wastes

The dye sorption abilities of various agricultural origin materials or those of the by-product have been investigated so far are sawdust (Ozakar and Zenkil, 2005), pith (Chen *et al* 2001), date pits (Banat *et al*,2003), barley husk (Robinson *et al*,2002),cattle bone carbon (Adetuti and Jabar 2010),wheat straw (Nigam *et al*,2000),orange peel (Rajeshwarisivaraj *et* al, 2001),and tree fern (Ho,2003). Sawdust is an effective material for the removal of dyes from waste water, state Garg *et al*, (2004). These materials are available in large quantities and may have potential as sorbents due to their physic- chemical characteristics and low cost, reports Crini (2005).

2.2.2 Recent Trends in Decolorization

Soil aquifer treatment systems, root zone method, equalization of effluent, diffused or wet air oxidation ionization, catalytic oxidation electrochemical treatment, bioaugmentation with microbes, immobilized microbes and incineration are the most recently developed technologies for liquid effluent treatment. They are considered to be cheaper than conventional treatment plants and at the same time, efficient in the removal of color and pathogens. Soil aquifer treatment processes are biological processes using fixed bacteria. The soil aquifer treatment system, in addition to its remarkable disinfecting powers, enables the aquifer to be used to store treated water, thus protecting it from evaporation and loss and permitting natural transfer of this valuable resource to agricultural wells, states Bhatia (2008).

Root zone method is a wetland method of sewage treatment and it depends upon the flow of sewage through soil. In root zone method waste water is treated by bacterial activity. Aerobic treatment takes place in the rhizosphere with anoxic and anaerobic treatment taking place in the surrounding soil. The advantages of root zone methods are, simple construction, low maintenance cost, consistent effluent quality and environmentally acceptable, reports Purohit (2008). Incineration can be used for industrial wastes and domestic wastes. The critical factors for effective combustion are the temperature, length of time at high temperature and the effective mixing of the waste with air. There are a number of combustion systems which will operate at 1500-3000^{o}C, the temperature required to breakdown organic wastes, which include rotary klins, liquid injection, fluidized beds and multiple hearth designs. The advantages of incineration are the reduction in volume and the ability to treat toxic materials, quote Scragg (2008) and Kaul *et al* (2002).

2.2.3 Sources Used For Decolorization

Activated carbons are made from a variety of materials including wood, lignin, bituminous coal, lignite and petroleum residue. Granular carbons produced from medium volatile bituminous coal or lignite have been most widely applied to the treatment of waste water, reports Eckenfelder (1999). Duckweed is capable of absorbing, accumulating and disintegrating a wide variety of substances, which are not easily biodegraded in conventional waste water treatment plants. A complete duckweed cover on the waste water may effectively prevent the development of algae in the water body and provides quiescent conditions, which contribute to a more clear effluent with lower total suspended solids, state Alaerts *et al* (1996).

2.3 SOIL

Soil is as important as water and air. A good quality soil acts as an environmental filter for cleaning air and water. Soil is the ultimate receptor and reservoir of nutrients released from organic matter, and remark Dubey and Maheshwari (2009). Soil is the outer region of earth-crust consisting of loose material formed by gradual weathering of rock, and gives to plant both mechanical and nutritional support. Soil is a complex product of parental material, or geology, topography, climate, time and biological activity on anthropogenic activity, exhorts Griffin (1999). Soil form from rocks through a complex process of physical, chemical and biological forces that reduce rock first to regolith and then to soil. Soil contain vastly diverse microbial communities, express Atlas and Bartha (2005). The sources of the mineral components of soil are called parent materials; the parent material can be either residual or transported. Alluvial is the term given to soils deposited by river flow, determine Subramanyam and Sambamurty (2000).

Soil is always rich in organic matter (humus and microorganisms), mineral substances, moisture, etc. Soil is sufficiently rich in oxygen, defines Purohit (2004).Every soil has a succession of layer, known as profile, reaching down to the parent material. The soil profile consists of two or more layers, called horizons. The soil horizons may vary in thickness, mineral composition and structure, quote Rangaswamy and Bagyaraj(2007). Each type of soil is characterized by the presence of different horizons, which can be seen when a soil profile is obtained. The horizon is formed and differentiated by the accumulation of organic matter and its decomposition products through microbial activities, suggests Rao(2007).

2.3.1 Properties of Soil

Soil minerals are divided into sand particles, silt particles and clay particles, express Gray and Williams (1999). Clay particles are negatively charged particles which are the important components of soil environment, state Pepper et al (2000). Humic substances are those portions of the soil organic matter that have undergone sufficient transformation to render the parent material unrecognizable. Humic compounds are random polymers. Humic materials present in mineral soils constitute less than 10% by weight of the soil, remarks Purohit (2008). The soil organic matter derives from the remains of plants, animals and microbes. Some soils or soil layers are aerobic, where as others are anaerobic, that is, there is no free oxygen in the soil atmosphere. Even in aerobic soil layers, there are anoxic regions devoid of free oxygen, cite Espantalion et al (2003).

Soil texture is very important property for the ecology of microorganisms because it describes the surface area that is available as a habitat for the growth of microorganisms. Soils with great clay compositions have much higher surface areas than soils with high sand concentrations, because clays are much smaller particles than sand articulates properties. These differences influence how many and what type of microorganisms can occupy the particular soil habitat, states Hazel (1995).

2.3.2 Types of Soil

Soil is the thin layer on the surface of the earth on which are living beings survive. It is the layer of materials in which plants have their roots. Soil is made up of many things like weathered rock particles and decayed plant and animal matter. Depending on the size of the particles in the soil, it can be classified into these following types; Sandy soil, Silty soil, Clay soil, Loamy soil, Peaty soil and Chalky soil, state Pepper et al (2000).

Sandy Soil has the biggest particles and the size of the particles does determine the degree of aeration and drainage that the soil allows. It is granular and consists of rock and mineral particles that are very small. Sandy soil retains moisture and nutrients. (http://www.buzzle.com).Silty Soil is one of the most fertile of soils. It can occur in nature as soil or as suspended sediment in water column of a water body on the surface of the earth. It is composed of minerals like Quartz and fine organic particles. It is granular like sandy soil but it has more nutrients than sandy soil. In case silty soil is dry it has a smoother texture and looks like dark sand. This type of soil can hold more moisture and at times becomes compact, states Rao (2007).

Clay Soil is a kind of material that occurs naturally and consists of very fine grained material with very less air spaces that is the reason it is difficult to work with since the drainage in this soil is low. When wet the clay soil becomes very heavy. Clay soil is formed after years of rock disintegration and weathering. It is also formed as sedimentary deposits after the rock is weathered, eroded and transported, remarks Purohit (2004). Loamy Soil consists of sand, silt and clay to some extent. It is considered to be the perfect soil. The texture is gritty and retains water very easily. There are various kinds of loamy soil ranging from fertile to very muddy and thick sod. Yet out of all the different kinds of soil loamy soil is the ideal for cultivation, express Subramanyam and Sambamurty (2000).

Peaty Soil is basically formed by the accumulation of dead and decayed organic matter; it naturally contains much more organic matter than most of the soils. It is generally found in marshy areas. The decomposition of the organic matter in Peaty soil is blocked by the acidity of the soil. This kind of soil is formed in wet climate. Though the soil is rich in organic matter, nutrients present are fewer in this soil type than any other type. Peaty soil is prone to water logging, report Dubey and Maheshwari (2009).Chalky Soil is very alkaline in nature and consists of a large number of stones. The fertility of this kind of soil depends on the depth of the soil that is on the bed of chalk. It is prone to dryness and in summers it is a poor choice for plantation, emphasize Atlas and Bartha (2005).

32.4 DIRECT DYE

Direct dyes are water soluble dyes, having affinity for cellulosic fibers. The name 'direct dye' dye alludes to the fact that these dyes do not require any form of 'fixing', insists Mangal(2010). These are sodium salts of aromatic sulphonic acids and when dissolved in water, ionize into the dye anion and sodium cation, states Shenai (2010). Direct dyes are also called substantive colors because of their excellent substantivity for cellulosic textile materials. The fibers most readily colored with direct dyes are the man-made and natural cellulosic fibers, ie, cotton and viscose fibers, expresses Mahadevan (2008).

2.4.1 Properties of Direct Dye

Direct dyes have poor washing fastness and poor light fastness. A relatively short exposure to direct sunlight is enough to initiate degradation of the dye molecule, determine Parmer *et al* (2008). Cellulosic textile materials dyed with direct dyes have comparatively poor wash fastness, because relatively large number of auxochromes the direct dyes anion which contributes to the aqueous solubility of these dyes contributes to the poor wash fastness of this class of dye, quotes Manahan (2000). Direct dyes are the easiest to produce, the simplest to apply, and the cheapest in their initial cost as well as in application. The one advantage is that direct dyes may be more light fast than reactive dyes, reports Corbman (2000).

2.5 BASIC DYE

Basic dyes are also called cationic dyes, because in solution the basic dye molecule ionizes, causing its colored component to become a cation or positively charged radical. The fibers most radically colored with basic dyes are mainly the synthetic acrylic and modacrylic fibers, states Pellew (2007). The first coal tar dye is generally known as basic dye. Basic dye is a type of dye that colors wool and silk without a mordant, reports Conway (1997).

2.5.1 Properties of Basic Dye

Dyed and printed acrylic textiles using basic dyes have excellent light fastness. This excellent light fastness is attributed partly to the hydrophobic nature of acrylic fibers, which minimizes their absorption of water and their excellent resistance to sunlight, remarks Beach (2008). Acrylic textiles dyed with basic dyes have very good wash fastness. The hydrophobic nature of acrylic fibers minimizing the absorption of water into the polymer system of acrylic fibers. The wash fastness rating of basic dye is about 4-5, quotes (NIIR). Basic dye is the first synthetic dye belongs to this group of dyes. The bright colors achieved from basic dyes do not usually occur with other dye classes; determine Gohl and Vilensky (1999). The most brilliant dyes among all synthetic dyes are found in this class of dyes, says Shenai (2000).

2.6 RECYCLING OF TREATED WATER FOR IRRIGATION

Agriculture is considered as the backbone of the Indian economy, say Ragothaman and Trivedy (2002).The re-use of waste water for agricultural purposes is an age old and common practice. An alternative and less expensive method is to use the treated water for irrigation to raise crops. Agricultural re- use is advantageous because waste water treatment requirements are often moderate, waste water contains plant nutrients and soil amendments, report Hammer and Hammer (2004). Irrigation is an old act as old as civilization, but for the whole world, it is a modern science, the science of survival, remarks Bhatia (2008).

2.7 WATER IN THE TEXTILE INDUSTRY

Textile industries consume substantial volumes of water and chemicals for wet processing of textiles. These chemicals are used for desizing, scouring, bleaching, dyeing, printing and finishing. Color is the first contaminant to be recognized in waste water and has to be removed before discharging into water bodies or on land. The presence of very small amount of dyes in water is highly visible and affects the aesthetic merit, water transparency and gas solubility in lakes, rivers and other water bodies, report Nigam *et al* (1995). Water has been a cheaper commodity for a very long period and never accounted for in processing cost. Now it becomes scarce and priced commodity and the cost for water and its treatments have escalated to the newer heights necessitating its inclusion in the production costs, opines Prasad (2004). Water is one of the most important factors for the textile industry. Soft water is ideal for wet processes so that the achievement of desired results is appropriate and most optimum, remark Teli *et al* (2004).

2.7.1 Environmental Hazards Due To Textile Effluent

Textile wet processing is one of the oldest and largest industries worldwide, responsible for the substantial resource consumption and pollution especially in terms of water view, state Omelchenko *et al* (2005). The process produce considerable amount of waste water, which is polluted by the use of dyes and other harmful additives, remarks Galgate (2001). Effluent derived from textile and dye stuff activities can provide serious environmental impact in the neighboring receptor water bodies because of the presence of toxic dyes and chlorolignin residues, reports Iyer (2000). Toxic chemicals such as chromium and sulphates may destroy fishes and microorganisms responsible for self purification of water in streams, view Saed *et al* (2005).Due to large scale production and extensive application, synthetic dyes can cause considerable environmental pollution and are serious health risk factors, state Forgacs *et al* (2004). Effluent that emanate from the production process of textiles, if not properly disposed can cause severe environmental pollution, sometimes to level that can threaten human health, livestock, wild life, aquatic lives and indeed the entire eco system, explain Sheth and Desai (2005).

Commercially, textile waste generation is influenced by the production of textile goods, higher the production, the greater the amount of waste. The management of waste is a formidable problem, says Mangal (2010). Textile waste effluents are one of the waste waters that are very difficult to treat satisfactorily because they are highly variable in composition and contain several different recalcitrant compounds. Waste waters that are generated at various stages of the dyeing process differ in compositions and temperature, determines Palit (2010). Wet processing of textile industry gives valuable effects to the clothing sector but in the same time waste effluents from that industry pollute the environment in many ways, insist Rathinamoorthy and Sumothi (2010).

Textile industry effluents exhibit large amounts of dye chemicals, which create severe water pollution. It is therefore important to reduce the dye concentration in the wastewater before discharging into the environment. The textile wastewater, which includes high color, high suspended solids, and dissolved organics comes from dye houses, emphasize Yoo *et al* (2001). The textile industry wastewater is rated as the most polluting among all industrial sectors in terms of both volume and composition of the effluents, report Vanndevivera *et al* (1998) and Lopez *et al* (2006). The color in these wastewaters is due to synthetic dyes left unused due to industrial inefficiencies. Presently over 10,000 different dyes and pigments are used in dyeing and printing industries all over the world. The total world colorant production is estimated to be 800,000 tons per year and at least 10-15% of the used dyestuff enters the environment through wastes, embark Palmieri *et al* (2005) and Levin *et al* (2004).

2.7.2 Utilization of Treated Water for Dyeing

The practice of discharging treated waste water to surface waters and withdrawal downstream is not considered reuse as dilution and separation in time and space allow additional purification to take place. Reuse of waste water involves the direct application of treated waste water for agricultural irrigation, industrial reuses, urban irrigation and dyeing. Water recycling presents a global challenge to the textile wet processing industry, which, like many industries using large volume of water, produces an effluent requiring specialist treatment before discharge, state Katkar *et al* (2010).

Most of the water demanding industries and agriculture sectors can be satisfied with water of less than potable water quality. Recycling of aqueous dye house effluent is of growing interest as the cost of water and effluent treatment rises and water becomes an increasingly scarce resource. The treated water is most often used for rinsing and washing but focus has also been given in its reuse in dyeing process, report Hub *et al* (2003).

2.7.2.1 Cotton

2.7.2.1.1 History of Cotton

Cotton is the oldest fiber used for textile purpose, state Ajay *et al* (2007). It is a fiber that grows from the surface of seeds in the pods, or bolls, of a bushy mallow plant. It is composed basically of a substance called cellulose. Cotton has been cultivated for more than 5000 years. Cotton was being grown on the Greek main land from the 18th century. Cotton is defined as white fibrous substance covering seeds harvested from cotton plant. India was the centre for world's cotton industry as well as variety of fine fabrics till 1600AD. China and Japan introduced cotton from India only in 800AD. But extensive cultivation was started from 1300AD, reports Corbman (2000).

Cotton the "King of Fibers" is closely linked to human civilization. Cotton remains the most miraculous fiber under the sun and no other fiber comes close to duplicating the entire desirable characteristic combined in cotton (www.cotton.org). Cotton is comfortable, strong, durable, has good color retention and is good to print on. Cotton is a fiber which is good for all seasons (library.thinkquest.org). In textile sector cotton accounts for 56% of the total fiber consumption and more than 75% in spinning mills. Average of 20-24 million metric tons per year cotton is produced in over 50 countries worldwide, in that 655 of cotton producers are in China, India and Pakistan, report Furter *et al* (2007).

Cotton is the most widely used cellulose fiber in the world because of its versatility and ability to provide good comfort particularly in apparel items, suggests Maithra (2007).cotton is appreciated for its naturalness. Demand for cotton is as strong as ever with new developments appearing constantly and its consumption has increased at an average annual growth rate of 2 percent. Since World War II attention has shifted to developing countries, more to China, where manufacturing is concentrated, report Textiles (2008). Cotton is an important source of an income for millions of small farmers and contributes significantly to the natural economy of many developing countries. Cotton has always ruled the textile world so it is rightly known as the "king" of fibers, remark Smith (2006) and Mullik (1995).

2.7.2.1.2 Properties of Cotton

Cotton fiber made up of cellulose which constitute approximately 90%. In addition to this water is 5-8 % and the rest weight is contributed by other natural impurities. Cotton fiber is very strong as compared to other natural fibers, state Gupta *et al* (2008). Cotton is comfortable, strong, durable, good color retention and it withstands high temperature, stand up to abrasion and wears well. Cotton's strength increases by 25 % when wet. Cotton fiber boast for its properties, like good absorption of fluid, drapability, breathability, biodegradability, sterilisability, insulation, non- allergic, non- irritation, heat resistant, high wet strength and water retention, express Collier and Tortora (2001). All bleaching agents can be safely used on white cotton but these are avoided for colored fabrics. Strong acids destroy the fibers but dilute acids have little or no effect, the fiber dissolve in strong acids, expresses Rastogi (2009). Cotton has resistance to alkali. Mild alkalis do not affect cotton. Strong alkalis of higher concentration induce structural and physical change in cotton fiber, reports Mishra (2000).

Experimental procedure

3. EXPERIMENTAL PROCEDURE

The experimental procedure adopted for the present study “**Decolorization of Direct and Basic Dye Solutions Using River Soil”** is discussed under following headings.

3.1 Selection of Sample

3.2 Selection of Dye

3.3 Optimization of Different Parameters for Decolorization of Direct and Basic Dye solutions using River Soil

3.4 Utilization of Treated Water for Irrigation Purpose

3.5 Utilization of Treated Water for Dyeing Cotton Fabric

3.6 Evaluation

3.7 Statistical Analysis

3.1 SELECTION OF SAMPLE

Dyes can be adsorbed onto several low cost natural materials and special material based on inorganic particulate synthetic soil have been developed for the adsorption of dye waste, states Hazel(1995).The adsorption process at solid or liquid interface has been extensively employed for many reasons, mainly due to its efficiency and economy, quote Espantalion et al (2003).The adsorption technique is superior to other techniques with regard to simplicity of design, initial cost, ease of operation and insensitivity to toxic substances. Soil material is a low cost adsorbent, and the river soil has more surface area than other soils so it can absorb more dye materials, report Parvathy et al (2010). Hence river soil was selected as the source for decolorization.

3.1.2 Collection of sample

The soil sample was collected from Ashtamudi River, Kerala.

3.1.3 Drying of sample

The soil sample was taken in a polythene cover and dried (Plate I) under the sunlight for 36 hours. Later it was stored in clean covers.

3.2 SELECTION OF DYES

Direct dyes are the easiest to produce, the simplest to apply, and the cheapest in their initial cost as well as in application and it is commonly used to dye the cotton fabrics, remark Parmer *et al* (2008). Basic dyes are characterized by their brilliance and intense hues. Basics dyes are commonly used for the dyeing of silk fabrics, embarks Beach (2008). Hence, direct and basic dyes were selected for the preparation of dye solutions.

3.3 OPTIMIZATION OF DIFFERENT PARAMETERS FOR DECOLORIZATION OF DYE SOLUTIONS USING RIVER SOIL

The optimum amount of dye concentration, soil concentration, time, temperature and pH required for dye water treatment were determined for proper and effective process.

3.3.1 Effect of Dye Concentration

Take 100 ml of water in three 250ml beaker. Then optimum decolorization medium was developed by varying the direct dye stuff concentration (0.01, 0.02, 0.03). Then the direct dye solution was treated with 4gms of river soil and incubated for 24 hour incubation at room temperature. After the incubation period, the absorbance was measured by using UV-vis spectrophotometer at 618nm. In the same manner basic dye was processed and the absorbance was measured by using UV- vis spectrophotometer (Plate II) at 588nm.

3.3.2 Effect of Soil Concentration

Hundred ml of 0.02% direct dye and 0.01% basic dye solutions were taken in six different 250ml beakers. Then add river soil in different concentrations (2%, 4%, and 6%) and kept for 24hour incubation at room temperature. After incubation period, the percent decolorization was determined, by using UV-vis spectrophotometer at 618nm. In the same manner basic dye was processed and the absorbance was measured by using UV- vis spectrophotometer at 588nm.

3.3.3 Effect of Time

To determine the effect of time on decolorization, 100mlof 0.02% of direct dye solution was taken in a 250ml beaker and was inoculated with river soil at a concentration of 4% and incubated for different time intervals(6,12,18,24 hours) at room temperature and then the percent decolorization was determined, by using UV-vis spectrophotometer at 618nm. In the same manner basic dye was processed and the absorbance was measured by using UV- vis spectrophotometer at 588nm.

3.3.4 Effect of Temperature

To evaluate the optimum temperature for decolorization, 100ml of 0.02%direct dye and 0.01% of basic dye solutions were taken in ten different 250ml beakers. Then beakers were incubated with river soil at a concentration of 4%. Then the beakers were incubated (Plate III and plate IV) at different temperature such as 30,40,50,60 and 70^0C for 24 hours. After incubation period percent decolorization was calculated, by using UV-vis spectrophotometer at 618nm. In the same manner basic dye was processed and the absorbance was measured by using UV- vis spectrophotometer at 588nm.

3.3.5 Effect of pH

To determine the effect of pH on decolorization, 0.02%direct dye and 0.01% basic dye solutions were adjusted to 5,6,7,8 and 9 pH (plate V)using one normality HCl and one normality NaOH. The solution adjusted with different pH was added with 4% of soil and incubated for optimized incubation period (24 hours) at room temperature. After incubation period the percent decolorization was determined, by using UV-vis spectrophotometer at 618nm. In the same manner basic dye was processed and the absorbance was measured by using UV- vis spectrophotometer at 588nm.

Direct dye water and basic dye water was decolorized under optimum conditions (Plate VI and plate VII). Take 0.6gm of direct dye and 0.3gm of basic dye in two stainless steel vessels, both containing three litres of water. Mix the solutions well. Then both the dye solutions were treated with 40 gms of river soil in the vessels at 30^0Cfor 24 hours. After treatment, both the treated waters were filtered using muslin cloth. Pair of three litres of beakers was taken and then the clean waters were stored in it. These treated effluents were utilized for dyeing and irrigation purpose.

3.4 UTILIZATION OF TREATED WATER FOR IRRIGATION PURPOSE

The practice of discharging treated waste water to surface waters and withdrawal downstream is not considered reuse as dilution and separation in time and space allow additional purification to take place. Reuse of waste water involves the direct application of treated waste water for agricultural irrigation, re-dyeing and industrial reuses. Agricultural reuse is advantageous because waste water treatment requirements are often moderate, waste water contains plant nutrients and soil amendments, state Hammer and Hammer (2004). Hence to assess the efficiency of the decolored water, the investigator conducted a plant study.

3.4.1 Selection of Plants

The plants selected for assessing the growth characteristics were green gram and green peas because of its easy availability, commercial importance and largely used by the people because of its nutritive importance. Green peas are an excellent source of folic acid, potassium and magnesium, thiamine, iron, zinc, phosphorus, copper and a source of fiber. (http://www.answers.com/topic/mung-bean#ixzz1JwUXoBAG). Green gram is an excellent source of iron, folic acid, magnesium, thiamine, pantothenic acid, vitamin B6 and phosphorus. Green gram is high in vitamin A, vitamin C, B vitamins and lutein state Weaver *et al* (1997).

In order to check the growth of the selected plants, six covers were selected. Red loamy soil and sand were selected and filled in 50:50 proportions in six plastic covers. Above the soil – sand mixture, a bed layer of pure sand was filled for one inch and three streaks were made over the sand. The seeds of green gram and green peas were randomly selected and sown in the streaks and slightly covered by sand. The first cover marked as A, was treated as control of the green gram plant, and fed with soft water. The second cover B was fed with direct dye treated water. The third cover marked as C was treated as control of green peas plant and fed with soft water. The fourth cover D was fed with basic dye treated water. The fifth cover E and sixth cover F were fed with pure solution of direct dye and basic dye respectively. All the covers were kept under uniform condition of sunlight and watered regularly.

3.4.2 Determination of Biometric Parameters of Plants

After sowing the seeds, germination percentage and vigour index were calculated for 7th (Plate VIII) and 14th days (Plate IX).

Germination % ═ no: of seeds germinated / no: of seeds sown ×100

Vigor index ═ germination % × (root length + shoot length)

On 7th (plate X and plate XI) and 14th (plate XII and plate XIII) day after sowing, all the samples were tested for parameters like chlorophyll, carbohydrate and protein content.

Nomenclature

The nomenclature of the plant samples thus selected for the study is given below.

TABLE I

NOMENCLATURE OF PLANT SAMPLES

Description	Code
Green Gram Plant fed with Tap Water	A
Green Gram Plant fed with Direct Dye Treated Water	B
Green Gram Plant fed with Direct Dye water	C
Green Peas Plant fed with Tap Water	D
Green Peas Plant fed with Basic Dye Treated Water	E
Green Peas Plant fed with Basic Dye Water	F

3.4.3 Biochemical parameters of plants

3.4.3.1 Estimation of Chlorophyll

Chlorophylls are the essential components of photosynthesis, and occur in chloroplasts as green pigments in all photosynthetic plant tissues. They are bound loosely to proteins but are readily extracted in organic solvents such as acetone or ether. Chemically each chlorophyll molecule contains a porphyrin (tetrapyrole) nucleus with a chelated Mg atom at the centre and a long chain hydrocarbon (phytyl) side chain attached through a carboxylic acid group. There are at least five types of chlorophylls in plants. Chlorophyll a and b occur in higher plants, ferns and mosses. Chlorophylls c, d and e are only found in algae and in certain bacteria, state Sadasivan and Manickam(2003).

Principle

Chlorophyll is extracted in 80% acetone and the absorption at 663nm and 665nm are read in a spectrophotometer. Using the absorption coefficients, the amount of chlorophyll is calculated.

Materials

Dilute analytical grade acetone to 80% acetone (prechilled).

Procedure

Weighed one gm of finely cut and well mixed representative sample of leaf or fruit tissue into a clean mortar. Ground the tissue to a fine pulp with the addition of 20ml of 80% acetone. Centrifuge (5000 rpm for 5 minute) and transferred the supernatant to a 100 ml volumetric flask. Ground the residue with 20 ml of 80% acetone, centrifuge and transfer the supernatant to the same volumetric flask. Repeated this procedure until the residue is colorless. Wash the mortar and pestle thoroughly with 80% acetone and collect the clear washings (Plate IV) in the volumetric flask. Make up the volume to 100 ml with 80% acetone, read the absorbance of the solution at 645, 663 and 652 nm against the solvent (80% acetone) blank.

3.4.3.2 Determination of Total Carbohydrate

Carbohydrates are the important contents of storage and structural materials in plants. They exist as free sugars and polysaccharides. (http://www.buzzle.com). The basic units of carbohydrates are the monosaccharide which cannot be split by hydrolysis into simpler sugars. The carbohydrate content can be measured by hydrolyzing the polysaccharides into simpler sugars by acid hydrolysis and estimating the resultant monosaccharide. (http://www.mamashealth.com).

Principle

Carbohydrates are first hydrolyzed into simple sugars using dilute hydrochloric acid. In hot acidic medium glucose is dehydrated to hydroxymethyl furfural. This compound forms with anthrone a green colored product with an absorption maximum at 630 nm.

Materials

2.5 normality HCl

Anthrone Reagent – Dissolve 200mg anthrone in 100 ml of ice cold 95% sulfuric acid. Prepare fresh before use.

Standard Glucose: Stock- Dissolve 100 mg in 100 ml water.

Working standard – 10 ml stock diluted to 100 ml with distilled water. Store refrigerated after adding a few drops of toluene.

Procedure

Weighed 100 mg of the sample into boiling tube. Hydrolyze by keeping it in a boiling water bath for three hours with five ml of 2.5 N- HCl and cool to room temperature. Neutralized it with solid sodium carbonate until the effervescence ceases. Make up the volume to 100 ml and centrifuge. Collected the supernatant and took 0.5 and one ml aliquots for analysis. Prepared the standards by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of the working standard, ‘zero’ serves as blank. Make up the volume to one ml in all the tubes including the sample tubes by adding distilled water. Then add four ml of anthrone reagent. Heat for 8 minutes in a boiling water bath. Cool rapidly and read the green to dark green color at 630 nm. Drawn a standard graph by plotting concentration of the standard on the X- axis versus absorbance on the Y- axis. From the graph calculate the amount of carbohydrate present in the sample tube.

3.4.3.3 Estimation of Protein

Proteins are large, complex molecules that play many critical roles in the body. They do most of the work in cells and are required for the structure, function, and regulation of the body’s tissues and organs. (http://www.articlesbase.com). Protein can be estimated by different methods as described by Lowry: and also by estimating the total ‘N’ content. No method is 100% sensitive. Hydrolyzing the protein and estimating the amino acids alone will give the exact quantification. The method developed is sensitive enough to give a moderately constant value and hence largely followed. Protein content of enzyme extracts is usually determined by this method. (http://ghr.nlm.nih.gov/handbook/howgeneswork/protein).

Principle

The blue color developed by the reduction of the phosphomolybdic phosphotungstic components in the Folin- Ciocalteu reagent by the amino acids tyrosine and tryptophan present in the protein plus the color developed by the biuret reaction of the protein with the alkaline cupric tartrate are measured in Lowry's method.

Materials

2% sodium carbonate in 0.1 N sodium hydroxide (Reagent A)

0.5% copper sulphate in 1% sodium potassium tartrate (Reagent B)

Alkaline copper solution: Mix 50 ml of A and 1 ml of B prior to use (Reagent C)

Folin – Ciocalteu Reagent (Reagent D)

Protein solution (Stock standard) – Weigh accurately 50 mg of bovine serum albumin and dissolve in distilled water and make up to 50 ml in a standard flask.

Working standard – Dilute 10 ml of the stock solution to 50 ml with distilled water in a standard flask.

Procedure

Extraction of protein from sample

Extraction is usually carried out with buffers used for enzyme assay. Weigh 500 mg of the sample and grind well with a pestle and mortar in 5- 10 ml of the buffer. Centrifuge and use the supernatant for protein estimation.

Estimation of protein

Pipette out 0.2, 0.4, 0.6, 0.8 and 1 ml of the working standard into a series of test tubes. Pipette out 0.1 ml and 0.2 ml of the sample extract in two other test tubes. Make up the volume to one ml in all the test tubes. A tube with one ml of water serves as blank. Added five ml of reagent C to each tube including the blank. Mix well and allow to stand for 10 minutes. Then add 0.5 ml of reagent D, mix well and incubate at room temperature in the dark for 30 minutes. Blue color is developed. Take the readings at 660 nm. Draw a standard graph and calculate the amount of protein in the sample.

3.5 UTILIZATION OF TREATED WATER FOR DYEING COTTON FABRIC

In view of rapidly growing shortage of renewable water resources in many parts of the world there is a growing interest in the use of treated effluents from waste water treatment plants. Recycling is a key concept of modern waste water management. Recycling is the reprocessing of waste materials into new or reusable product, state Katkar and Bairgadar (2010). Color in the textile effluent cannot be removed by simple operation. Hence decolorizing the dye effluent before its use for further dyeing is the only practical way to reduce pollution, view Bardhan and Sule (2004). An additional cost required for effluent treatment incurred, simply for legitimate disposal, this creates the concept of revising the treated effluent. The water which is suitable for return to the environment is acceptable for reuse in preparation and dyeing, reports Singh (2004). Considering these facts the investigetor asserted the suitability of decolorized water for dyeing.

3.5.1 Selection of Fabric

Cotton is one of the most important fibers in the world of textiles. Cotton is an abundant natural fiber having various advantages such as availability, comfortability, excellent heat conductivity, high wet strength, easily sterilizable and hydroscopic in nature, states Singh (2007). Cotton fabrics have a pleasant feel and handle, says Sekar (2001). It is a natural fiber chemically known as cellulose. It has a high degree of acceptability to wear next to skin such as shirts, blouses, trousers because of its high adsorption and swelling capacity regarding aqueous solution, insists Gienandt (2006). Plain weave is relatively inexpensive for construction and can be extensively used for cotton fabrics. Their ravel was less when compared with the fabric of other weaves, expresses Kaplan (2002). Hence, cotton fabric made out of plain weave was selected for the present study.

3.5.2 Selection of Dye

Apart from basic requirements like compatibility, consistency, reproducibility and right first time approach, it should have added values like ideal profile of substantivity, exhaustion and fixation rate, excellent level dyeing properties, high fastness properties and should meet the requirements of ecological standards, remarks Mahapatra (2005). The direct dye is more light fast than reactive dye (http://www.britannica.com). The direct dye may also be applied to dyeing without the use of mordant to fix the dye once it is applied.(http://jaaigowrisarees.com). Direct dye is selected for the present study because of its ease of application and brilliance of shade (http://articles.textileclass.com).

3.5.3 Dyeing of Cotton with Direct Dye using Treated and Soft water dyeing procedure

Dyeing implies some affinity between the fiber and the dye, reports Barker (1998). In dyeing affinity essentially means the preferential attraction of the dye for the fiber rather than for a solution of the dye bath, state Khurana and Meena (2010). In most of the dyeing houses, direct dyes are used as they are easy to apply, good leveling property, cheapest in initial cost and no auxiliary chemicals such as mordant are needed. Direct dyes may be more light fast, that is, resistant to fading in the light, than fiber reactive dyes, quotes Mahadevan (2008). The process for direct dyeing of cotton can be divided into three steps (pre-treatment, dyeing and rinsing after dyeing) and the dyeing parameters are presented in Table II.

TABLE II
DYEING PARAMETERS

Fabric weight	1 meter (58 gm)
shade	3%
Material: liquor ratio	1;30 ml (1740 ml)
Sodium chloride	60%
temperature	85^0C

During the pretreatment (Desizing), 58 gm of cotton fabric was taken, weighed in an electronic balance. Based upon the fabric weight water was taken 1:30 ratio in a clean stainless steel vessel. Two gm of detergent was added and mixed well. The was immersed in the solution and boiled for 30 minutes. Then the sample was taken from the vessel and rinsed in soft water and dried.

The desized cotton material (58gm) was taken and weighed using an electronic balance. The amount of dye solution (1740 ml) and chemicals were calculated. The dye stuff was made into paste with few drops of wetting agent and required amount of hot water was poured according to the strength of the dye solution with constant stirring. The dye bath was prepared by taking the calculated amount of dye (1.74 gm) solution and water. The soda ash (1.16 gm) solution was added to the dye bath in order to increase the solubility of the dye bath. The temperature of dye bath was raised 85-95^{o}C in 15 minutes and the material was immersed in the dye bath. After ten minutes the material was removed from the dye bath and sodium chloride was added and mixed well. The material was returned to the dye bath and the temperature was slowly increased over a period of 30 minutes the material was removed from the dye bath and rinsed well in water. Following the same procedure, dyeing was performed using decolored water of direct dye and basic dye.

Nomenclature

The nomenclature of the samples thus selected for the study is given below.

TABLE III

NOMENCLATURE OF THE SAMPLES

Samples	Code
Original Fabric	O
Soft Water Dyed Sample	SDS
Direct Dye Treated Water Dyed Sample	DDS
Basic Dye Treated Water Dyed Sample	BDS

3.6 EVALUATION

3.6.1 Subjective Evaluation

The soft water and treated water dye samples were evaluated visually by a panel, of 25 judges comprising of PG students specializing in the field of Textile and Clothing. General appearance, brilliancy of shade, and evenness of dyeing were the main aspects taken into consideration for visual evaluation. The samples were neatly cut and pasted on a white chart. The judges are given a performance (Appendix I) to rate the dyed samples.

3.6.2 Objective Evaluation

Textile testing as a whole refers to the vigor testing done on textile materials which may be inside the laboratory as well as in the natural settings, states Raul (2005).

3.6.2.1 Fabric Weight

Fabric weight is the relative weight of the fabric and expressed as the weight of the particular size of a piece as grams per square meter or ounces per square yard, remark Angappan and Gopalakrishnan (2006).

Fabric weight of the original and dyed samples was determined using GSM cutter (Plate XV). It is a device to cut circular specimen of 100 square centimeters of a fabric very accurately. It has four blades that cut the fabric when the hand wheel is rotated by applying light pressure. The samples were cut and weighted accurately using digital balance having 0.01sensitivity. The value in grams multiplied by 100 gives grams per square meter on the fabric. The samples were weighted for ten times and the mean value was calculated and recorded.

3.6.2.2 Fabric Thickness

The principle of measuring fabric thickness in BIS(2000) states that “Essentially, the determination of the thickness of a compressible material such as a textile fabric consist of the precise measurement of the distance between two plane parallel plates as the pressure foot and the other as the anvil”.

Thickness gauge tester (Plate XVI) was used to determine the thickness of the original and dyed samples. A clock- type dial gauge is built into a thickness tester. It should be rigidly mounted in a suitable frame after setting to zero. The gauge is also consists of a pressure foot and anvil. The sample is placed between the cleaned pressure foot and anvil without any pressure. The reading shown by the dial is noted down. Thickness was determined at ten different places away from two inch of the selvedge of the selected samples. The gauge is capable of measuring to an accuracy of 1 percent for cloth of 5 / 1000 inch or more, and to 0.00005 inch for thinner fabric.

3.6.2.3 Fabric Strength and Elongation

Tensile strength is the maximum tensile force recorded by extending the test piece to breaking point. Elongation is the increase in length of a specimen during tension test, expressed in unit length of the fabric when loaded, reports Saville (2004). The samples of original and dyed fabrics were tested for tensile strength using Eureka cloth tensile strength tester 12”×12” specimen from each sample was cut both in warp and weft direction of the fabric, 2” apart from selvedge. The specimen was placed between the upper and lower clamp. The dial reading was set to zero by adjusting the pendulum over the quadrant scale. The elongation pointer was checked for its position in zero. Before starting the machine the pendulum lock was released and machine was switched on to run. At the point of fabric started to break, the machine was switched off and the dial reading in kg was taken. Elongation reading was noted from the elongation scale. The specimen was removed and the machine positioned back to original and the ten specimens of both warp and weft directions from each sample were tested and readings were noted.

3.6.2.4 Fabric Stiffness

Fabric stiffness is defined as the resistance of a fabric to bending. Stiffness test measures the bending stiffness of a fabric by allowing a narrow strip of the fabric to bend to a fixed angle under its own weight. The length of the fabric required to bend to this angle is measure and is known as the bending length. The most commonly used instrument for measurement of stiffness of a fabric is Shirley stiffness tester (Plate XVII). A rectangular strip of fabric, 6”×1” was cut with the aid of a template and then both the template and the specimen were transferred to the platform with the fabric underneath. Both were pushed forward slowly. The strip of the fabric commence to drop over the edge of the platform and the movement of the template and the fabric was continued until the tip of the specimen viewed in the mirror cuts both index lines. The bending length can immediately be read from the scale marked opposite to zero on the line engraved on the sides of the platform. Each specimen was tested four times, at each end and again with the strip turned over. Mean value of the bending length in warp and weft wise direction was calculated.

3.6.2.5 Fabric Drape

Drape is the term used to describe the way a fabric hangs under its own weight. It has an important bearing on how good a garment looks in use. To determine drapability Eureka drape meter (Plate XVIII) was used. Five samples were cut according to the size of the templates. A brown paper was also cut to the same size of the fabric. Each sample was placed between two small circular plates, so that its free edges drape down under their own weight. Image of the draped samples found on the brown paper was traced and cut along the outline. It was weighted using an electronic balance. A drape co- efficient was calculated for each sample using the formula.

$$\text{Drape co- efficient} = W_s - W_d / W_D - W_d$$

W_S = Weight of the paper whose area is equal to the projected area of the specimen.

W_d = Weight of the paper whose area is equal to the area of the supporting disc.

W_D = Weight of the paper whose area is equal to the area of the specimen.

3.6.2.6 Crease Recovery

Crease recovery is the ability of a fabric resist creasing and is depend on the type of fiber used in its construction. The ability of a fabric to resist creasing is in the first instance dependent on the type of fiber used in its construction, reveals Saville (2004). The basic principle of this test is that a small fabric specimen is folded into half and placed under a load for a given length of time to form a crease and it is then allowed to recover for a further length of time and the angle of crease that remains is measured. The magnitude of this crease recovery angle is an indication of the ability of a fabric to recover from accidental creasing.

Eureka Crease Recovery Tester was used for the study. The instrument consists of a circular dial which carries the clamp for holding the sample. A knife edge and index line was seen directly under the centre of the dial for measuring the recovery angle. Ten samples each 5 ×2.5cm sizes were cut both in the warp and weft directions. In the test samples were folded into two and were placed under 10N loads for five min. they were then transferred immediately to the fabric clamp on the instrument and allowed to recover from the crease. After two minutes, the dial was rotated to keep the free edge of the sample coincide with the knife edge. The crease recovery angle in degree was read directly from the engraved scale. The mean value was calculated and recorded for all the ten samples.

3.6.2.7 Abrasion Resistance

The ability of material to resist the action of abrasive forces is clearly one of the major criteria to take into account when assessing durability. Abrasion is just one aspect of wear and is the rubbing away of the component fibers and yarns of the fabric, states Booth (1996).

The Eureka Martindale Abrasion Resistance Tester (Plate XIX) was designed to give controlled amount of abrasion between fabric surfaces at comparatively low pressures in continuously changing directions. The severity of abrasion varies with the nature of the abradant. Ten samples were cut at random from each of the dyed materials and original using the template. The initial weight of each sample was measured using an electronic balance. The samples were mounted on sample holders. The sample holders with 200 grams weight were used for this purpose. The rubs were standardized to 30 rotations. After 30 rotations, the samples were removed and the final weight of each sample was found out. Weight loss due to abrasion was calculated. The same procedure was repeated for all other samples and the mean value was calculated. Each time, a fresh abradant was used. Similarly the mean value of the ten readings for each of the sample was calculated and thus the loss in weight of each material was recorded separately.

3.6.2.8Absorbency Test

Drop Test

Drop test is a count of the number of drops required to penetrate through the underside of the fabric when all the drops fall on to the same spot remark Grover and Hambey (2002).the dyed samples were fixed onto the embroidery frame and burette was used to drop water in the centre of the fabric. Time and number of drops were noted down for all the samples.

Sinking Test

This involves a simple test of wettability of fabric. In this test, a small square specimen about 1 inch ×1inch was cut and dropped it to the surface of water in a beaker. The time taken for the specimen to sink below the surface is observed. The shorter the time, the greater the wettability.

Capillary Rise Test

The capillary travel method measures the ability of absorption, emphasizes Booth (1996). Five pieces of samples were cut measuring 15cm length and 2.5cm width. One end of the sample strip was pasted with a glass rod which was placed on heavy wooden blocks and at the other end, two grams weight was attached to keep the sample straight. At the weighted end 2cm of the sample was allowed to immerse in a tray of distilled water. The rise of the water level in the strip was noted by keeping the time as constant (one minute).

3.6.2.9 Color Fastness Test

The color fastness of the textile is defined as its resistance to changes when subjected to a particular set of conditions. The fastness of dye depends upon the chemical structure of the colorant, dye concentration, environmental conditions, nature of fiber, atmospheric contaminants, presence of foreign substance and state of dye inside the fiber, express Paul *et al* (2003).

The grey scale (Appendix II) employed for color fastness test is 1-5. In this scale one means poor fastness and five represent excellent color fastness. It is expressed in terms of magnitude, reports Smith (2006). Four colorfastness tests such as color fastness to sunlight, washing, wet and dry crocking and wet and dry pressing were carried out.

Fastness to Sunlight

Color fastness of textile material to day light is of considerable importance. It is a measure if the ability of the molecule to absorb radiation without being destroyed, the absorbed radiation being dissipated in other ways, AATCC (2007).

To test the fastness to light the specimen of 16cm × 3cm were cut from each sample of dyed fabrics and divided into eight equal parts measured as two cm each. The specimens were covered with black chart. For successive seven days the specimens were exposed to direct sunlight. First day first portion of the specimens were exposed and accordingly seven portions were exposed to light. The first portion was exposed for seven days and the seventh portion was exposed for a day. The last portion was not exposed to sunlight and considered as standard for comparison. Comparison was done using grey scale and the specimens were rated.

Fastness to Washing

Major loss of color from the fabric is due to washing and result is staining over the adjacent fabric. This phenomenon is used in wash fastness of color.To test the wash fastness, the sample was twisted together with an equal quantity of white cloth and soaked in a natural solution of soap and water at a temperature of 50^0C for about 20 minutes. The sample was then squeezed out and dried. The color change of the dyed sample was measured by evaluating the color of the adjacent white fabric using grey scale.

Fastness to Crocking (Dry and Wet)

Crocking is the rubbing fastness of dyes. Color fastness to rubbing is a basic test to determine the quality of a colored fabric. This test is designed to determine the amount of color transferred from the surface of colored textile material to other surface by rubbing, remarks Booth (1996).it is applicable to textile made from all fibers in the form of yarn or fabric whether dyed, printed or otherwise colored.

Sasmira crock meter was used to determine the fastness to crocking. Each of dyed samples was cut in the measurement of 25 × 20 cm and mounted on flat base. The desized white cotton fabric was mounted in a ring on the rubbing finger. Each sample was given ten rubs based on standardization. The color transfer from the dyed sample to the white material was used for wet crocking. The same procedure adopted was same as that of dry crocking. The color transfer from the dyed sample to the white material was assessed using grey scale.

Fastness to Wet and Dry pressing

Color fastness of the samples to pressing was measured following the specification of BIS (2000). Two specimens measuring 10cm × 10cm from each dyed sample were cut and one set of specimens covered at either side with 5cm × 5cm of desized white fabric. The prepared specimens were pressed for five seconds to assess its color fastness to dry pressing while the others were covered with wet white cloth and pressed for five seconds to assess its color fastness to wet pressing. The same procedure was repeated for all the five samples. The color change in the dyed fabrics as well as color staining on the white fabric was graded using grey scale.

3.7 STATISTICAL ANALYSIS

The laboratory tests of fabric and biometric evaluation of plant results were analyzed statistically to compare the fabric dyed in soft water, direct and basic dye treated water. Analysis of Variance (ANOVA) is a useful tool, which helps the user to identify sources of variability from one or more potential sources, sometimes referred to as treatments of factors. It performs a comparison of the means of a number of replications of experiments performed where a single input factor is varied at different settings or levels (www.weibull.com).

After the data collection, it was essential to organize the information in a systematic manner, in order to obtain the desired results and interpret scientifically. The information thus collected was analyzed statistically and findings are given in Results and Discussion.

Results and discussion

4. RESULTS AND DISCUSSION

The results of the study entitled on **“Decolorization of Direct and Basic dye solutions using River Soil”** are discussed under the following headings.

4.1 Optimization of Different Parameters for the Decolorization of Direct and Basic dye Solutions Using River Soil.

4.2 Utilization of Treated Water for Growing Green gram and Green Peas plants.

4.3 Evaluation of Dyed Samples

4.4 Subjective Evaluation- Visual Inspection

4.5 Objective Evaluation

4.1 OPTIMIZATION OF DIFFERENT PARAMETERS FOR THE DECOLORIZATION OF DIRECT AND BASIC DYE SOLUTIONS USING RIVER SOIL.

4.1.1 Effect of Dye Concentration

The effect of direct dye concentration and basic dye concentration on the decolorization is determined and the results are presented in the Table IV and Figure 1.

TABLE IV

EFFECT OF DIRECT AND BASIC DYE CONCENTRATION

Direct Dye concentration (%)	Decolorization %	Basic dye concentration %	Decolorization %
0.01	94.2	0.01	97.8
0.02	99.4	0.02	91.9
0.03	91	0.03	90.5

From the Table IV and Figure I it is observed that at lower concentrations, the rate of decolorization is quite efficient. The percentage of decolorization in direct and basic dye is 99.4% and 97.8 with lowest concentration of 0.02% and 0.01% respectively. When the concentration is gradually increased as 0.01% to 0.03% in direct dye and 0.02% to 0.03% in basic dye, the percent decolorization of direct dye and basic dye are decreased as 94.2% to 91% and 91.9% to 90.5% respectively. Increased concentration of dye causes significant sludge formation, state Wu *et al* (2001). Hence it could be concluded that lower the concentration of dye, better the decolorization.

4.1.2 Effect of Soil Concentration

Effect of soil concentration on decolorization of direct dye and basic dye solutions are determined and the results are presented in Table V and Figure 2.

TABLE V
EFFECT OF SOIL CONCENTRATION

Soil Concentration %	Decolorization %	Soil Concentration %	Decolorization %
2	91	2	91
4	99.5	4	97.9
6	95.5	6	95.2

From the results it is evident that an increase in soil concentration of 2% to 4% the decolorization of effluent gradually increased whereas the percent decolorization seemed to be lowered in direct and basic dye solutions as (95.5%) and 95.2% respectively with an increased soil concentration of 6%. Hence an optimum soil of 4% was selected, as the percent decolorization of direct and basic solutions are obtained as 99.5% and 97.9% respectively. High percent of decolorization was due to dye absorption by soil as well as reduction in dye intensity in solution because of the higher concentration of soil,(Namasivayam, (2001)). Hence, it could be concluded that 4% of soil gives better decolorization than 2% and 6%.

4.1.3 Effect of Time

The effect of time on decolorization of direct dye and basic dye solutions by river soil are determined and the results are presented in the Tables VI and Figures 3.

TABLE VI
EFFECT OF TIME

Hours	Decolorization %	Hours	Decolorization %
6	95	6	90
12	96.1	12	92.3
18	97.4	18	96.5
24	99.4	24	98.2

It is clear from the Table VI that the maximum decolorization of direct and basic dye solutions (99.4 %and 98.2%) were seen at 24 hours of incubation period. Similar result was observed by Atun *et al* (2003) who has reported 97% decolorization of methylene blue by fuller's earth at 24 hours of incubation. Hence it could be concluded that 24 hours is enough to decolorize the dye effluents by using river soil.

4.1.4 Effect of pH

The results regarding the effect of pH on decolorization of direct and basic dye solutions are determined and reported in Table VII and Figure 4.

TABLE VII
EFFECT OF PH

pH	Decolorization %	pH	Decolorization %
5	99.3	5	92
6	99.2	6	94
7	98	7	97.8
8	98.6	8	93
9	98	9	93.5

The results show a significant effect of pH on the decolorization of both dyes. Soil showed better decolorization and degradation activities at 5 and 7 pH, state Bouberka *et al* (2005).This is also depicted in Figure (7),where the maximum color removal of direct and basic solutions (99.3% and 97.8%) were detected on pH 5and pH 7 respectively when compared to others. The decolorization was strongly inhibited at the pH on both 8 and 9. Hence it could be concluded that on low pH, the soil can decolorize the dye effluents.

4.1.5 Effect of Temperature

The results pertaining to the effect of temperature on decolorization of direct and basic dye solutions are determined and reported in Table VIII and Figure 5.

TABLE VIII
EFFECT OF TEMPERATURE

Temperature (^{0} C)	Decolorization %	Temperature (^{0} C)	Decolorization %
30	99.52	30	99.1
40	97	40	97.9
50	96	50	96.8
60	98.5	60	95.5
70	96	70	97

The maximum decolorization of direct and basic dye solutions (99.52% and 99.1%) was observed in the beakers incubated at 30^0C for one day under optimum condition. Significant percent decolorizations were observed as 98.5% in direct dye solution and 97.9% in basic dye solution at 60^0C and 40^0C respectively. Whereas Sabah *et al* (2002) view different soil have different color absorption rate, with most of them at 30-50^0C. Hence it could be concluded that the soil shows better decolorization of dye effluents on room temperature.

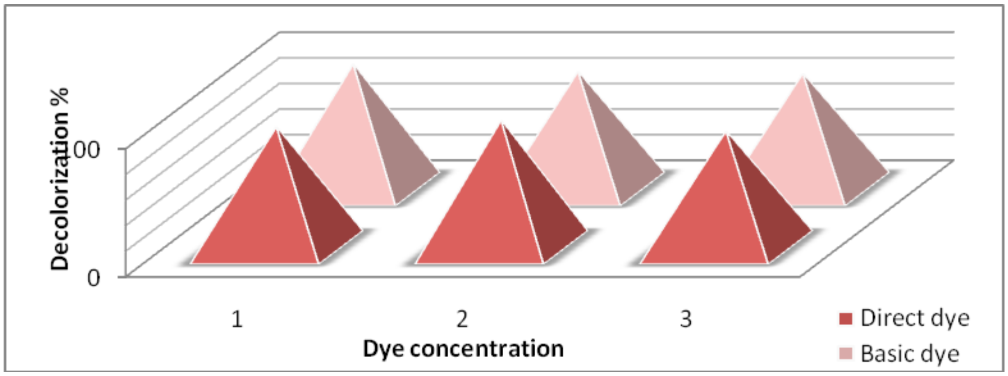

FIGURE 1

EFFECT OF DIRECT AND BASIC DYE CONCENTRATION

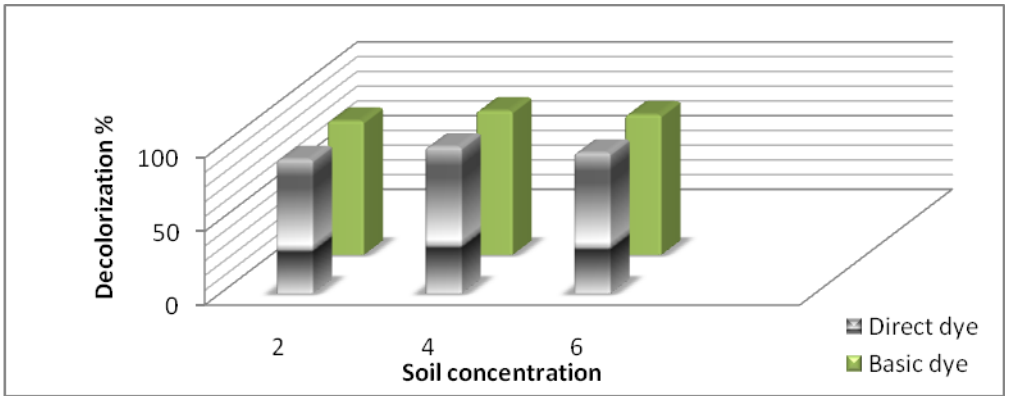

FIGURE 2

EFFECT OF SOIL CONCENTRATION

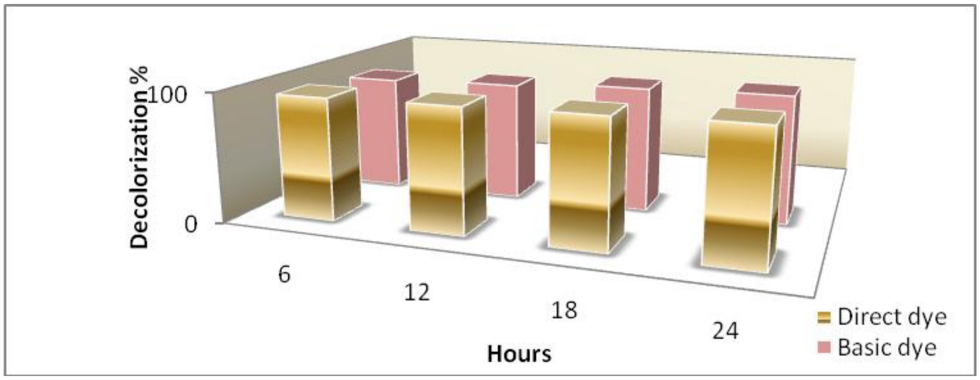

FIGURE 3

EFFECT OF TIME

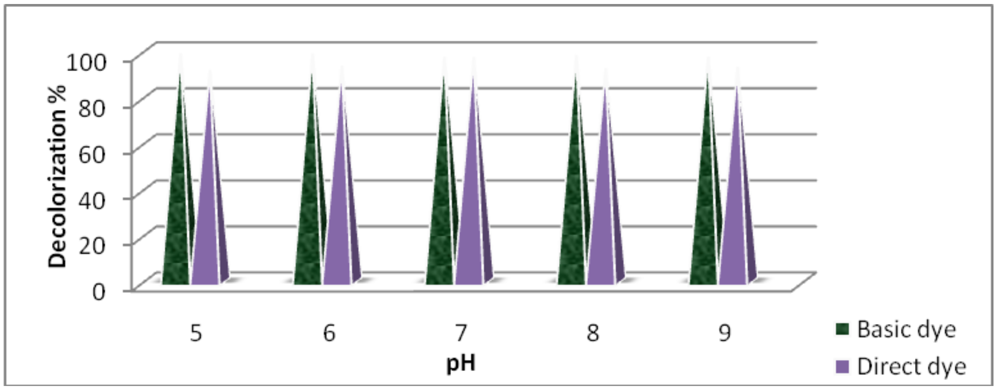

FIGURE 4

EFFECT OF PH

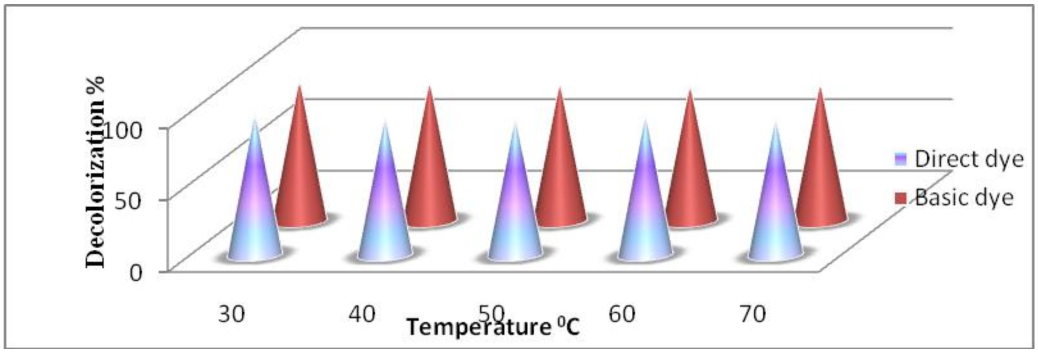

FIGURE 5

EFFECT OF TEMPERATURE

4.2 UTILIZATION OF TREATED WATER FOR GROWING GREEN GRAM AND GREEN PEAS PLANTS.

Effect of soft water, direct and basic dye solution and treated dye solutions on the biometric parameters and bio-chemical parameters are determined for the growth of green gram and green peas plants.

4.2.1 Effect of Direct Dye Solution, Basic Dye Solution and Treated Dye Solutions on the Biometric Parameters of Green gram and Green Peas Plants.

Biometric parameters such as germination percentage and vigor index are determined on the 7th and 14th day after seeding and the results are shown in Table IX and Figure 6.

TABLE IX

GERMINATION PERCENTAGE OF GREEN GRAM AND GREEN PEAS PLANTS ON 7TH AND 14TH DAY

Sample	Number of seeds sown	7th day		14th day	
		Number of seeds germinated	Germination percentage	Number of seeds germinated	Germination percentage
A	10	9	90	8	80
B	10	10	100	10	100
C	10	8	80	10	100
D	10	10	100	10	100
E	0	0	0	0	0
F	0	0	0	0	0

From the Table IX and Figure 6, it is clear that all the samples showed good germination percentage except E and F samples which have been watered with pure direct dye and pure basic dye solutions.

TABLE X
VIGOR INDEX OF GREEN GRAM AND GREEN PEAS PLANTS ON 7TH AND 14TH DAY

Sample	7th day			14th day		
	Root length (cm)	Shoot length (cm)	Vigor index	Root length (cm)	Shoot length (cm)	Vigor index
A	1.7	0.3	180	2.4	0.5	232
B	1.8	0.3	210	2.4	0.5	290
C	1.2	0.3	120	1.8	0.8	260
D	1.4	0.4	180	1.9	0.9	280
E	0	0	0	0	0	0
F	0	0	0	0	0	0

It can be observed from Table X and Figure 7 that vigor index increased in the order, Sample A< sample C< sample D< sample B. Maximum vigor index was seen in sample B, which had been watered with direct dye treated solution and nothing was grown in sample E and sample F, which had been watered with direct and basic dye solutions.

4.2.2 Effect of Direct Dye Solution, Basic Dye Solution and Treated Dye Solutions on the Biochemical Parameters of Green gram and Green Peas Plants.

Biochemical parameters like chlorophylls, total protein and total carbohydrate of green gram and green peas plant are estimated on 7th and 14th day and the results are presented below.

4.2.2.1 Chlorophyll

The effect of raw and dye treated water samples on total chlorophyll content (chlorophyll a + chlorophyll b) of green gram and green peas plant are estimated on 7th and 14th day and the results are expressed in Table XI and Figure 8.

TABLE XI
TOTAL CHLOROPHYLL CONTENT OF GREEN GRAM AND GREEN PEAS PLANTS ON 7TH AND 14TH DAY

Sample No	7th day			14th day		
	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total chlorophyll (mg/g)	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total Chlorophyll (mg/g)
A	0.11	0.09	0.41	0.07	0.08	0.006
B	0.004	0.14	0.06	0.14	0.18	0.11
C	0.12	0..15	0.08	0.14	0.14	0.07
D	0.16	0.11	0.08	0.23	0.15	0.12
E	0	0	0	0	0	0
F	0	0	0	0	0	0

From Table XI and Figure 8, it is evident that total chlorophyll content was high in sample A, which has been watered with plain water. All other samples showed lesser chlorophyll content in the order sample D>sample B>sample C>sample E and F. Hence, treated effluent can be effectively utilized for irrigating crops.

4.2.2.2 Protein

The total protein content of all the samples are determined on 7th and 14th day after sowing the seeds and the values are mentioned in Table XII and Figure 9.

TABLE XII

TOTAL PROTEIN CONTENT OF GREEN GRAM AND GREEN PEAS PLANTS ON 7TH AND14TH DAY

Sample No	Total protein (mg/g)	
	7th day	14th day
A	0.6	0.7
B	0.4	0.8
C	0.5	0.8
D	0.16	0.42
E	0	0
F	0	0

Table XII and Figure 9 show a study increment of protein contents in all the samples. Maximum protein content was reported in sample B and C, which had been watered with direct dye treated water and minimum value was observed in sample E and F, which had been watered with direct dye water and basic dye water. For all other samples, the protein content followed the following order, sample B and C>sample A >sample D.

4.2.2.3 Carbohydrate

Total carbohydrate content of each representative samples are calculated on 7th and 14th day using anthrone method and the results are depicted in Table XIII and Figure 10.

TABLE XIII
TOTAL CARBOHYDRATE CONTENT IN GREEN GRAM AND GREEN PEAS PLANTS ON 7TH AND 14TH DAY

Sample No	Total Carbohydrate (mg/g)	
	7th day	14th day
A	0.12	0.14
B	0.15	0.4
C	0.26	0.68
D	0.44	0.54
E	0	0
F	0	0

By analyzing the values presented in Table XIII and Figure 10, it is understood that carbohydrate content of all the samples has increased on 14th day than 7th day. Maximum carbohydrate content was observed in sample C and minimum carbohydrate content was observed in sample E and F, which was watered with direct and basic dye waters.

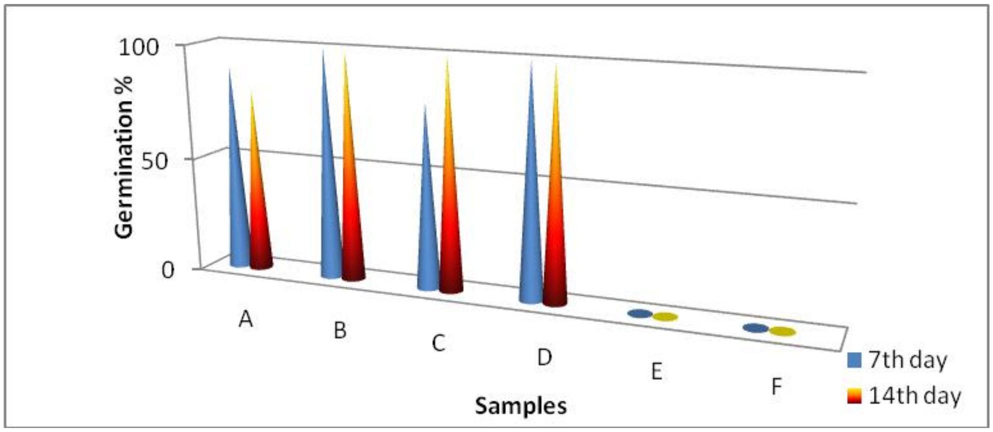

FIGURE 6
GERMINATION PERCENTAGE OF GREEN GRAM AND GREEN PEAS PLANTS ON 7TH AND 14TH DAY

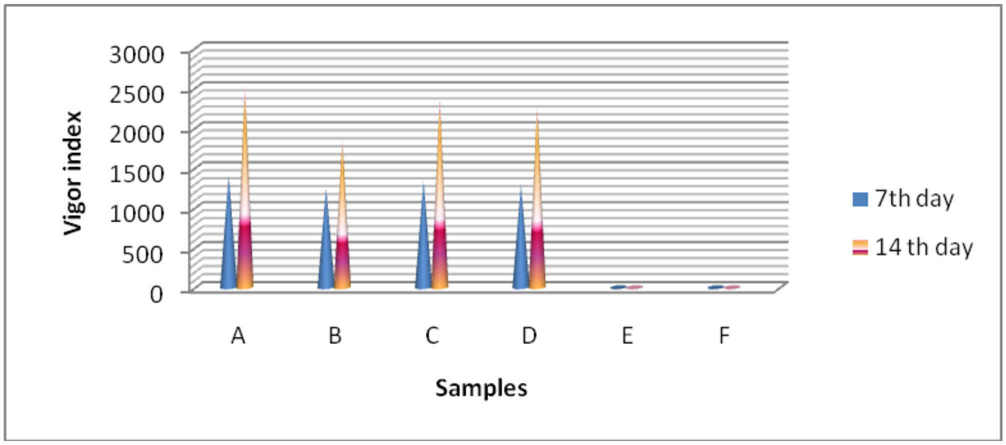

FIGURE 7
VIGOR INDEX OF GREEN GRAM AND GREEN PEAS PLANTS ON 7THAND 14TH DAY

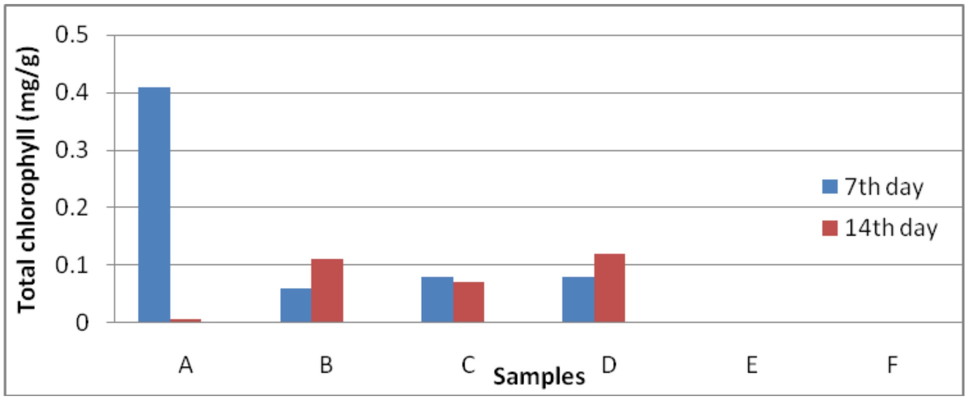

FIGURE 8
TOTAL CHLOROPHYLL CONTENT OF GREEN GRAM AND GREEN PEAS PLANTS ON 7TH AND 14TH DAY

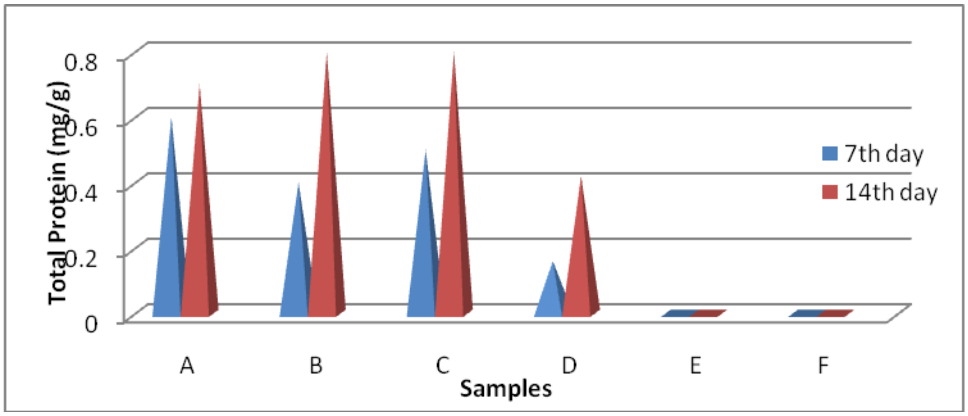

FIGURE 9
TOTAL PROTEIN CONTENT OF GREEN GRAM AND GREEN PEAS PLANTS ON 7TH AND 14TH DAY

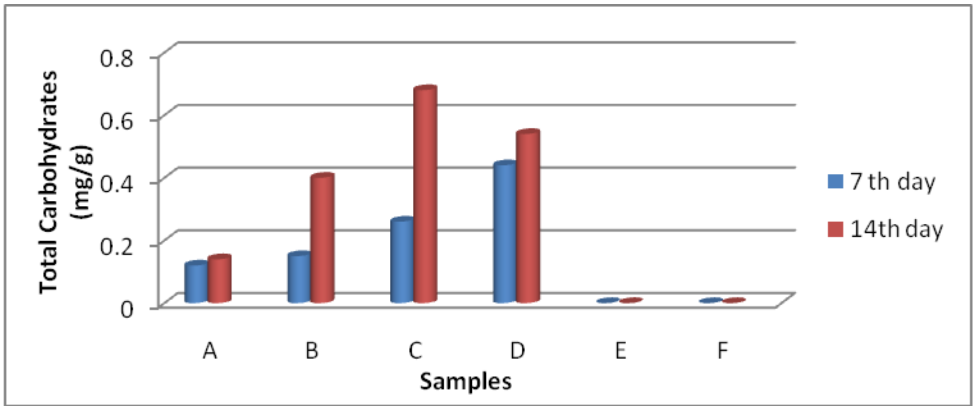

FIGURE 10
TOTAL CARBOHYDRATE CONTENT IN GREEN GRAM AND GREEN PEAS PLANTS ON 7TH AND 14TH DAY

4.3 EVALUATION OF DYED SAMPLES

4.4 SUBJECTIVE EVALUATION- VISUAL INSPECTION

The result of visual inspection is presented in Table XIV. The details of the panel rating include general appearance, evenness of dyeing and luster.

TABLE XIV

VISUAL INSPECTION OF FABRICS

Samples	General Appearance			Evenness of Dyeing		Luster		
	Good	Fair	Poor	Evenly Dyed	Unevenly Dyed	Bright	Medium	Dull
SDS	70	30	-	100	-	80	20	-
DDS	76	24	-	100	-	83	17	-
BDS	79	21	-	100	-	88	12	-

From the Table XIV, it is clear that the general appearance of the sample dyed with soft water was rated as good by 70% of judges where as DDS and BDS were rated to be good by 76% and 79% respectively. All samples were rated to be evenly dyed by 100 percent of the judges. With regard to luster 80% of the judges rated the SDS samples as bright, 83% of the judges rated the DDS samples as bright and 88% of the judges rated BDS samples as bright. Hence it could be concluded that the samples dyed with treated waters were better than the sample dyed with soft water.

4.5 OBJECTIVE EVALUATION

4.5.1 Fabric Weight

The fabric weight of the original and dyed samples and analysis of variance are presented in Table XV and Figure 11.

TABLE XV
FABRIC WEIGHT

Sr No	Samples	Mean Weight in GSM	Loss/gain over original	% loss/ gain over original	F value
1	O	1.10	0	0	54.7364**
2	SDS	1.12	0.02	2	
3	DDS	1.15	0.05	4.67	
4	BDS	1.14	0.04	3.92	

** Significant at 1% level

From the Table XV and Figure 11, it is clear that the weight of samples increased after dyeing compared to the original. The percent weight increase in 2%, 5% and 4% in SDS, DDS and BDS samples respectively. Statistical analysis proves that there was a significant difference at one percent level between the original and the dyed samples. Maximum increase in sample BDS in weight may be the result of more dye absorption. The results prove that the direct dye treated water can effectively used for dyeing cotton.

4.5.2 Fabric Thickness

The fabric thickness of original and dyed samples and analysis of variance are presented in Table XVI and Figure 12.

TABLE XVI
FABRIC THICKNESS

Sr No	Samples	Mean Thickness (mm)	Loss/gain over original	% loss/gain over original	F value
1	O	0.36	0	0	5.1332^{NS}
2	SDS	0.34	0.02	0.05	
3	DDS	0.33	0.03	0.08	
4	BDS	0.32	0.04	0.11	

NS-Not significant

From the Table XVI and Figure 12, it is evident that the thickness of the dyed samples increased when compared to the original. The percent increase in SDS was 0.05, DDS was 0.08 and BDS was 0.011respectively. Hence it could be included that dyeing increased the thickness of all the dyed samples irrespective of the type of water used.

4.5.3 Fabric Strength

Fabric Strength (warp)

Tensile strength in the warp direction and analysis of variance of the samples O, SDS, DDS and BDS are depicted in Table XVII and Figure 13.

TABLE XVII

FABRIC STRENGTH (WARP)

Sr No	Samples	Mean Strength(Kg)	Loss/gain over original	% loss/gain over original	F value
1	O	26	0	0	13.526*
2	SDS	34	8	8.8	
3	DDS	37.2	11.2	43	
4	BDS	38	12	46	

*Significant at 5% level

Fabric Strength (Weft)

The fabric strength of the samples in weft direction for original and dyed samples and analysis of variance are given in Table XVIII and Figure 14.

TABLE XVIII
FABRIC STRENGTH (WEFT)

Sr No	Samples	Mean Strength(Kg)	Loss/gain over original	% loss/gain over original	F value
1	O	36	0	0	5.486^{NS}
2	SDS	42.4	6.4	17	
3	DDS	45.2	9.8	26	
4	BDS	50.9	14.9	41	

NS- Not significant

From the Table XVII and Figure 13, strength of all the samples has increased after dyeing. The maximum increase is obtained in BDS sample as 38%.Hence it could be concluded that this may be due to the deposition of high percent of dye. Statistical analysis indicates that there is a significant difference at 5% level between samples.

From the Table XVIII and Figure 14, it is clear that there is increase in strength of all the samples along weft direction when compared with original. The increase in strength of samples SDS, DDS and BDS are 17 percent, 26 percent and 41 percent respectively. Statistical analysis indicates that there was no significant difference between the samples. From the result obtained and statistical analysis, it could be concluded that the strength of the BDS sample can be compared DDS sample and SDS sample, which proves that basic dye treated water can be utilized for dyeing process.

4.5.4 Fabric Elongation

Fabric Elongation (Warp)

Fabric elongation and analysis of variance of the samples O, SDS, DDS and BDS in the warp directions are presented in Table XIX and Figure 15.

TABLE XIX
FABRIC ELONGATION (WARP)

Sr No	Samples	Mean Elongation (inches)	Loss/gain over original	% loss/gain over original	F value
1	O	1.25	0	0	18.475**
2	SDS	1.40	0.15	12	
3	DDS	1.50	0.25	20	
4	BDS	1.50	0.25	20	

** Significant at 1% level

Fabric Elongation (Weft)

Elongation and analysis of variance of the samples O, SDS, DDS and BDS in the weft directions are presented in Table XX and Figure 16.

TABLE XX
FABRIC ELONGATION (WEFT)

Sr No	Samples	Mean Elongation (inches)	Loss/gain over original	% loss/gain over original	F value
1	O	0.95	0	0	2.0320^{NS}
2	SDS	1.12	0.17	18	
3	DDS	1.35	0.4	42	
4	BDS	1.35	0.4	42	

NS- Not significant

From the Table XIX and Figure 15, it is clear that there is an increase in elongation in the warp direction of all the dyed samples. The increase in elongation of samples SDS, DDS and BDS are 12 percent, 20 percent and 20 percent respectively along warp direction, when compared over the original. Statistical analysis indicates that there is a significant difference at 1% level between samples. It could be concluded that elongation has increased irrespective of the type of water used for dyeing.

From Table XX and Figure16, it is evident that SDS, DDS and BDS are increased in elongation by 18 percent, 42 percent and 42 percent respectively in weft direction when compared with original. The statistical analysis shows that there is no significant difference among samples.

4.5.5 Fabric Stiffness

Fabric Stiffness (Warp)

Fabric stiffness and analysis of variance of the samples O, SDS, DDS and BDS in the warp direction are presented in Table XXI and Figure 17.

TABLE XXI

FABRIC STIFFNESS (WARP)

Sr No	Samples	Mean Stiffness (cm)	Loss/gain over original	% loss/gain over original	F value
1	O	2.62	0	0	2.1623^{NS}
2	SDS	2.45	- 0.17	-6	
3	DDS	2.58	-0.04	-2	
4	BDS	2.55	-0.07	-3	

NS- Not significant

Fabric Stiffness (Weft)

Fabric stiffness and analysis of variance of the samples O, SDS, DDS and BDS in the weft direction are presented in Table XXII and Figure18.

TABLE XXII
FABRIC STIFFNESS (WEFT)

Sr No	Samples	Mean Stiffness (cm)	Loss/gain over original	% loss/gain over original	F value
1	O	2.46	0	0	1.48^{NS}
2	SDS	2.10	- 0.36	-15	
3	DDS	2.28	-0.18	-7	
4	BDS	2.26	-0.16	-8	

NS- Not significant

From the Table XXI and Figure 17, it is clear that the fabric stiffness of SDS, DDS and BDS samples were decreased by 6 percent, 2 percent and 3 percent respectively over original. Statistical analysis indicates that there is no significant difference between the samples.

From the Table XXII and Figure 18, it is clear that the stiffness of all the samples decreased after dyeing along weft direction. The fabric stiffness of SDS, DDS and BDS samples were decreased by 15 percent, 7 percent and 8 percent respectively over original. Statistical analysis indicates that there is no significant difference between the samples. Hence it could be concluded that the stiffness of the original fabric is reduced through dyeing.

4.5.6 Fabric Drape

Fabric drape coefficient of original and dyed samples is presented in Table XXIII and Figure 19.

TABLE XXIII
DRAPE CO-EFFICIENT

Sr No	Samples	Mean (g)	Loss/gain over original	% loss/gain over original	F value
1	O	0.68	0	0	20.754**
2	SDS	0.74	0.06	9	
3	DDS	0.80	0.12	17	
4	BDS	0.82	0.14	21	

** Significant at 1% level

From Table XXIII and Figure 19, it is evident that drape co- efficient increased in all the samples. Increase in drape co- efficient in SDS, DDS and BDS samples is found to be 9 percent, 17 percent and 21 percent respectively. Statistical analysis indicates that there is a significant difference at 1%level between samples.

4.5.7 Crease Recovery

Crease Recovery (Warp)

Crease recovery and analysis of variance of the samples O, SDS, DDS and BDS in the warp direction is presented in Table XXIV and Figure 20.

TABLE XXIV
CREASE RECOVERY (WARP)

Sr No	Samples	Mean Recovery (degree)	Loss/gain over original	% loss/gain over original	F value
1	O	112	0	0	1.3254^{NS}
2	SDS	118	6	5	
3	DDS	117	5	4	
4	BDS	117	5	4	

NS- Not significant

Crease Recovery (Weft)

Crease recovery and analysis of variance of the samples O, SDS, DDS and BDS in the weft direction are presented in Table XXV and Figure 21.

TABLE XXV
CREASE RECOVERY (WEFT)

Sr No	Samples	Mean Recovery (degree)	Loss/gain over original	% loss/gain over original	F value
1	O	109	0	0	4.2354^{NS}
2	SDS	111	2	2	
3	DDS	109	0	0	
4	BDS	110	1	1	

NS- Not significant

From the Table XXIV and Figure 20, it is evident that SDS, DDS and BDS samples show increased crease recovery by 5percent, 2 percent and 6 percent respectively in the warp direction when compared to original. Statistical analysis indicates that there is no significant difference between original and dyed samples. To conclude the BDS sample showed higher crease recovery angle when compared with SDS and DDS in the warp direction.

From the Table XXV and Figure 21, it is clear that when compared with original, SDS, DDS and BDS samples show an increased crease recovery of 4 percent, 7 percent and 7 percent respectively in the weft direction. However, there is no significant difference between original and dyed samples statistically.

4.5.8 Abrasion Resistance

Abrasion resistance of original and dyed samples and analysis of variance are presented in Table XXVI and Figure 22.

TABLE XXVI
ABRASION RESISTANCE

Sr No	Samples	Mean weight (g)	Loss/gain over original	% loss/gain over original	F value
1	O	0.06	0	0	2.4105^{NS}
2	SDS	0.04	-0.02	-33	
3	DDS	0.03	- 0.03	-50	
4	BDS	0.03	- 0.03	-50	

NS- Not significant

From the Table XXVI and Figure 22, it is evident that the dyed samples (SDS, DDS and BDS) showed decreased tolerance to abrasion resistance. In the case of SDS, DDS and BDS the percent of weight loss is 33, 50, and 50 respectively. Statistical analysis indicates that there is no significant difference among the samples.

4.5.9 Absorbency Tests

The results related to the absorbency of the samples are presented in the Table XXVII and Figure 23.

TABLE XXVII
ABSORBENCY TESTS

Sr No	Samples	Mean Capillary Rise in 60 sec (cm)	Drop Test (Seconds)	Sinking Test (Seconds)
1	O	2.12	0.97	1.15
2	SDS	3.65	0.20	0.58
3	DDS	4.00	0.17	0.52
4	BDS	4.02	0.18	0.54

From the Table XXVII and Figure 23, it could be concluded that in all the absorbency tests, treated water dyed samples (DDS and BDS) had taken minimum time for absorption when compared with soft water dyed samples. Hence treated water could be effectively replaced for treated water.

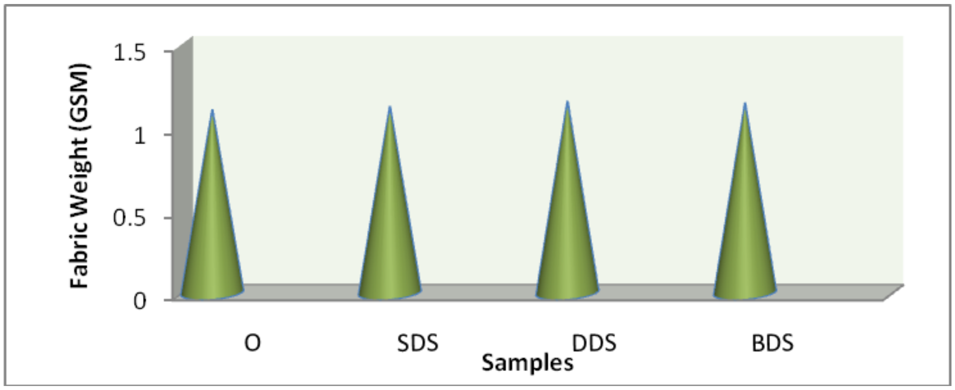

FIGURE 11

FABRIC WEIGHT

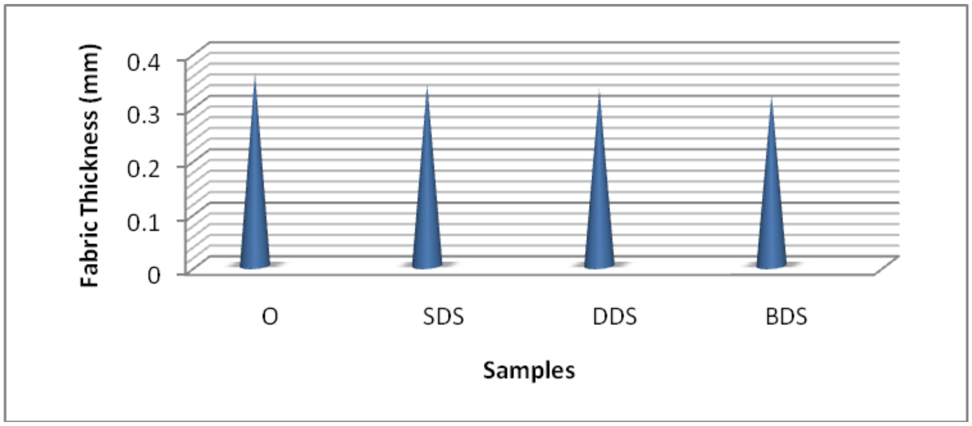

FIGURE 12

FABRIC THICKNESS

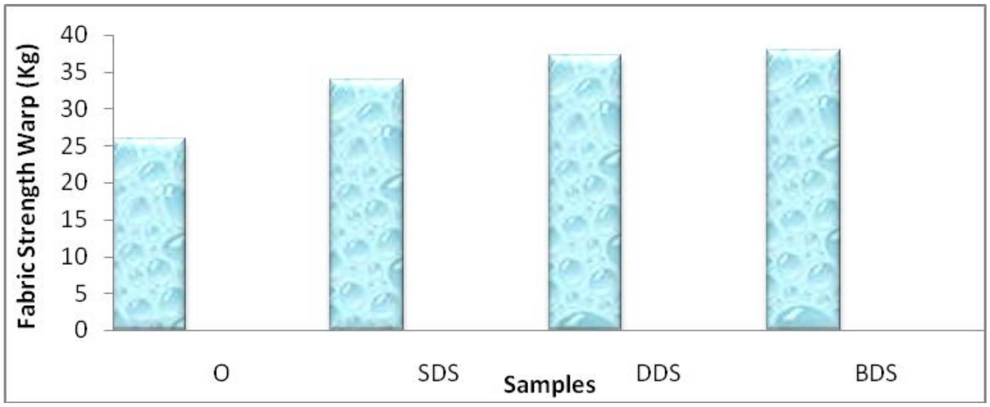

FIGURE 13
FABRIC STRENGTH (WARP)

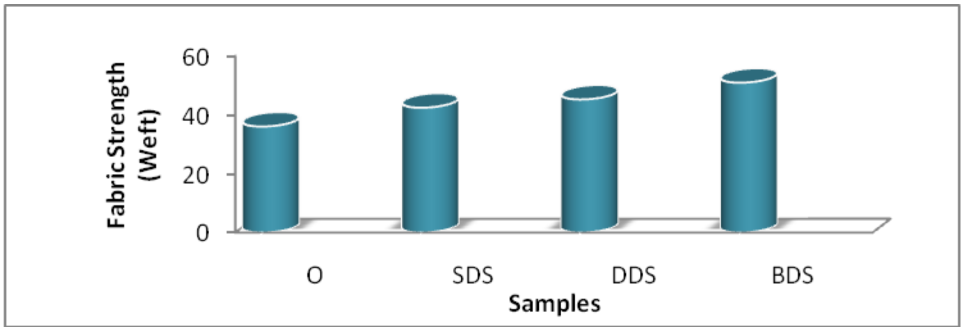

FIGURE 14
FABRIC STRENGTH (WEFT)

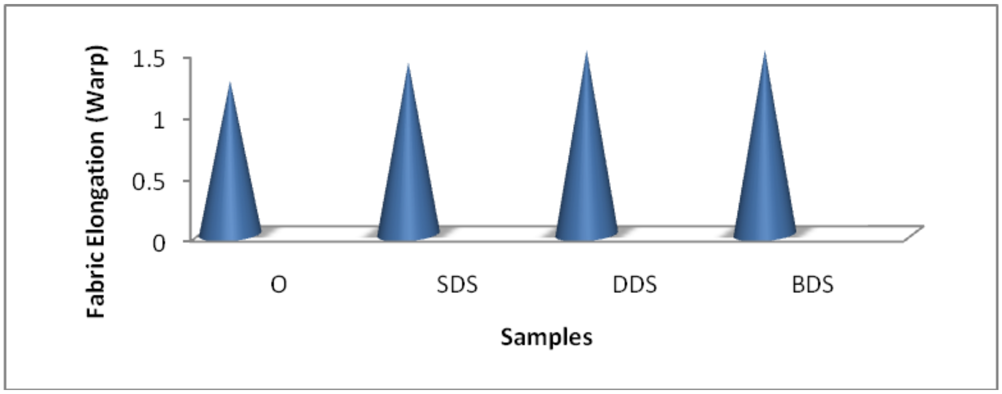

FIGURE 15
FABRIC ELONGATION (WARP)

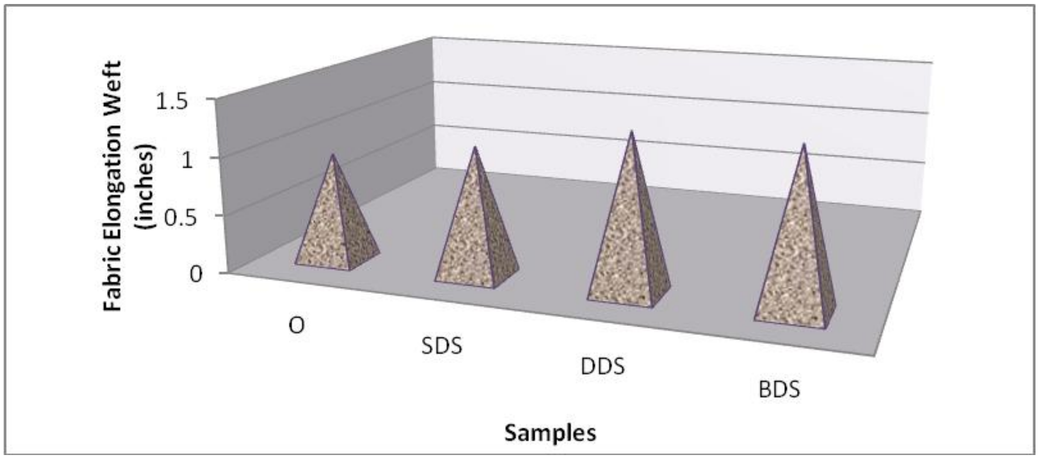

FIGURE 16
FABRIC ELONGATION (WEFT)

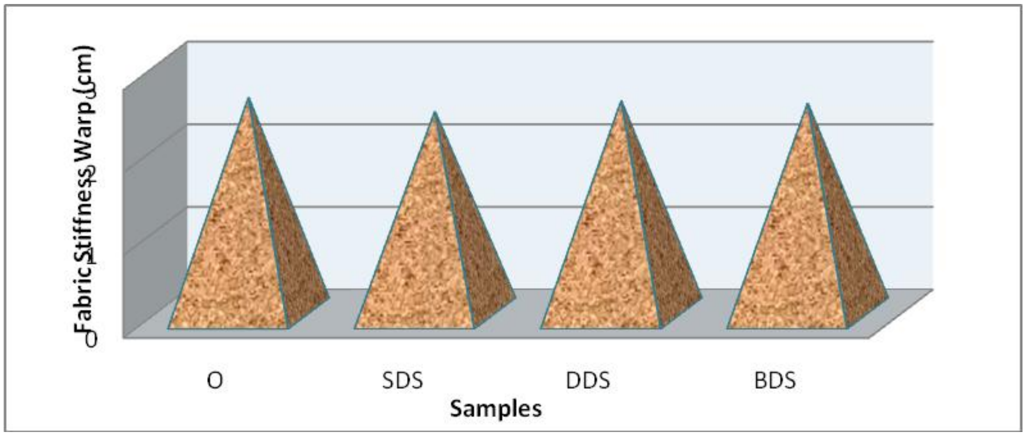

FIGURE 17
FABRIC STIFFNESS (WARP)

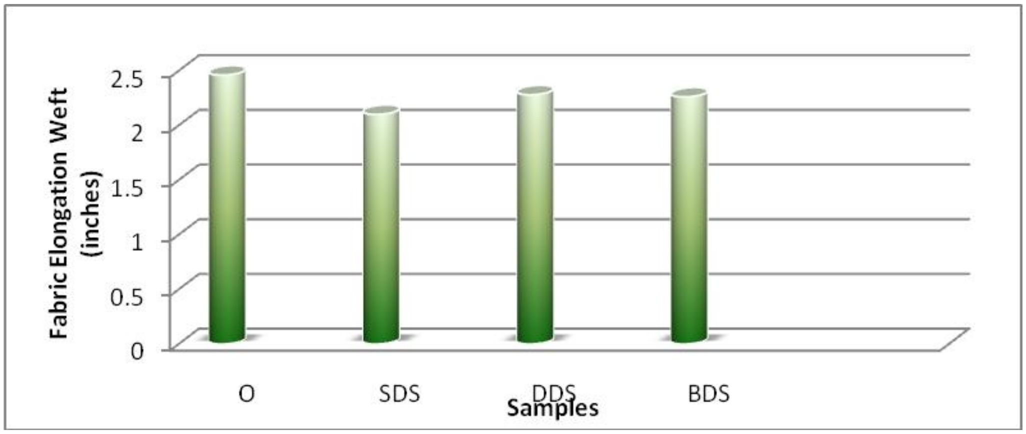

FIGURE 18
FABRIC STIFFNESS (WEFT)

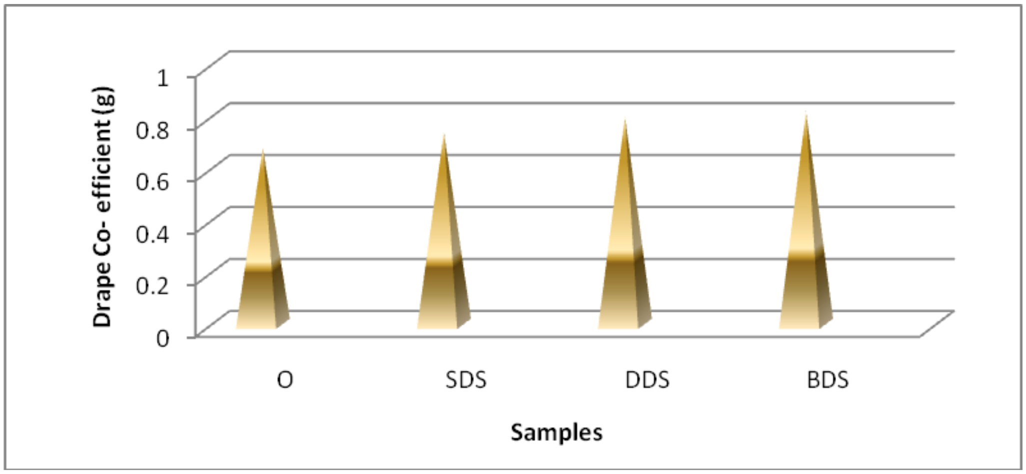

FIGURE 19
DRAPE CO-EFFICIENT

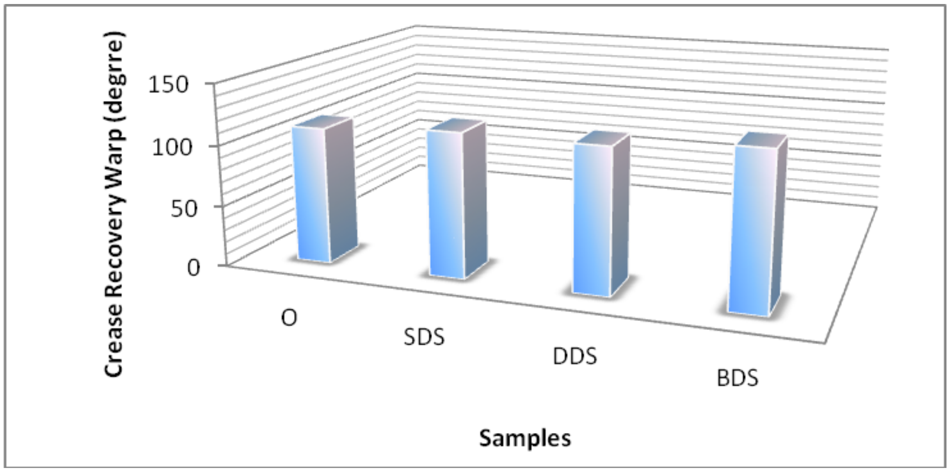

FIGURE 20

CREASE RECOVERY (WARP)

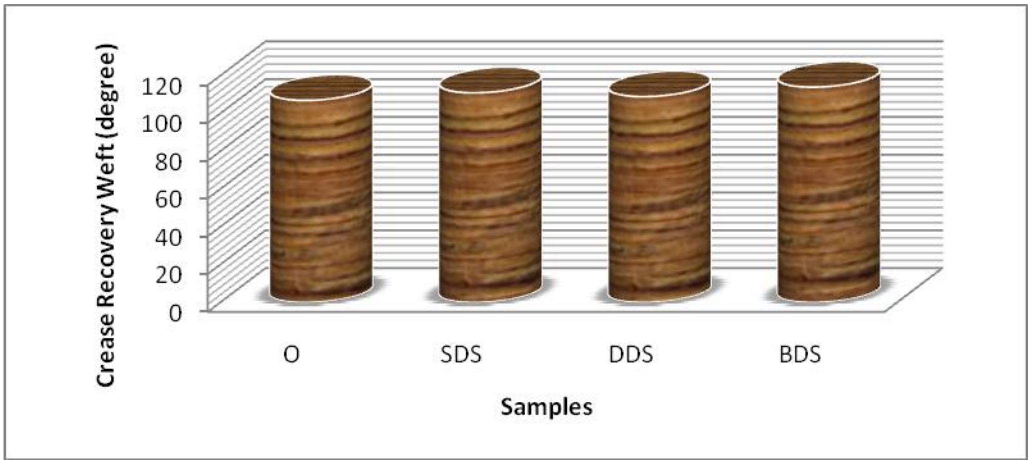

FIGURE 21
CREASE RECOVERY (WEFT)

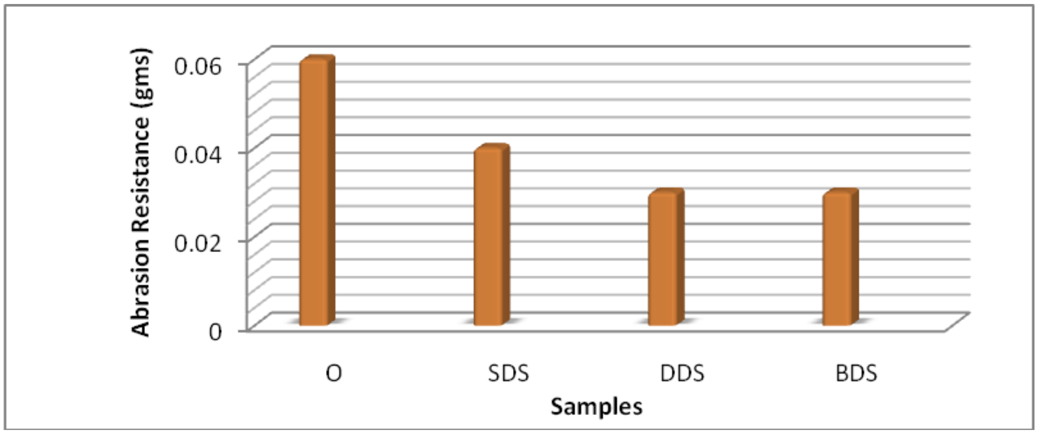

FIGURE 22
ABRASION RESISTANCE

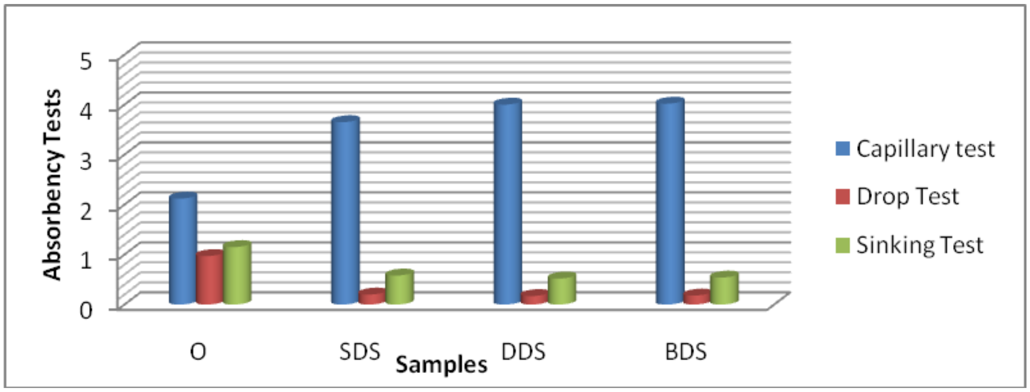

FIGURE 23
ABSORBENCY TESTS

4.5.10 Color Fastness Tests

Color fastness results of dyed fabrics to sunlight, pressing, crocking and washing are presented in Table XXVIII.

TABLE XXVIII
COLOR FASTNESS TEST

Sr No	Samples	Sunlight	Pressing		Crocking		Washing
			Dry staining	Wet staining	Dry crocking	Wet crocking	
1	SDS	4	4	4	4	4	4
2	DDS	4	5	4	5	5	4
3	BDS	4	5	4	5	5	4

SDS- Soft water dyed sample, DDS-Direct dye treated water dyed sample, BDS – Basic dye treated water dyed sample.

1. Very poor 2. Poor 3. Fair 4. Good 5. Excellent

From the Table XXVIII, it is evident that the dyed samples SDS, DDS and BDS had good fastness to sunlight, pressing and washing, in dry condition SDS sample had good fastness to pressing and samples of DDS and BDS had excellent fastness to pressing. In wet and dry crocking, SDS sample had good fastness to crocking whereas both DDS and BDS samples had excellent fastness to crocking. To conclude, DDS and BDS samples had excellent fastness to dry staining, dry crocking and good fastness to sunlight, wet pressing, wet crocking and washing.

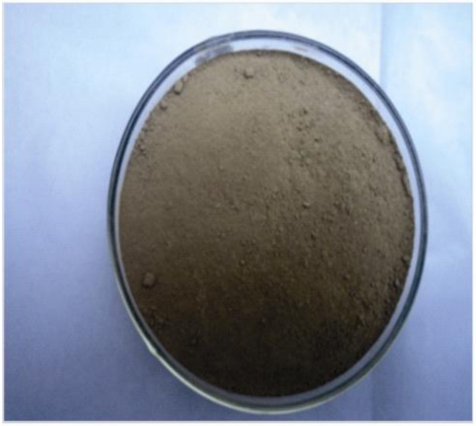

PLATE I
River Soil

PLATE II
Spectrophotometer

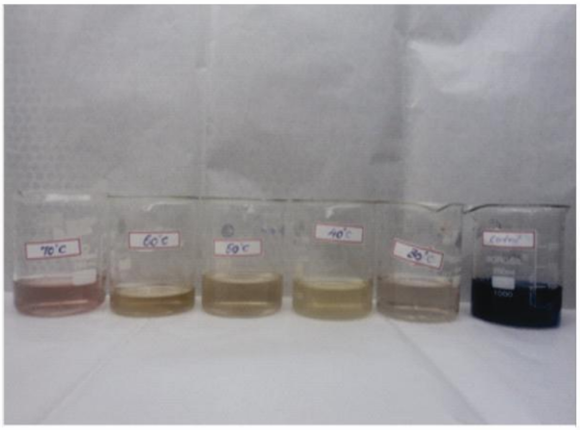

PLATE III
Temperature (Direct Dye)

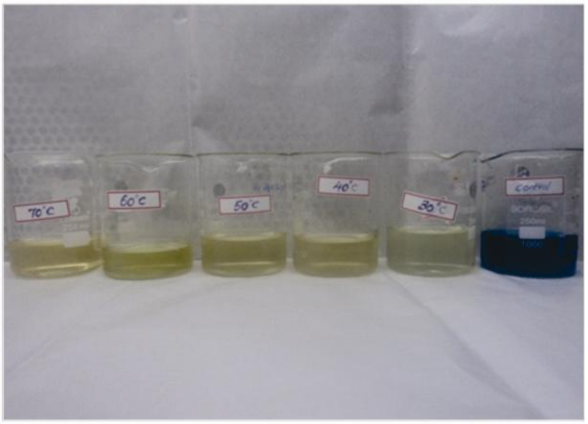

PLATE IV
Temperature (Basic Dye)

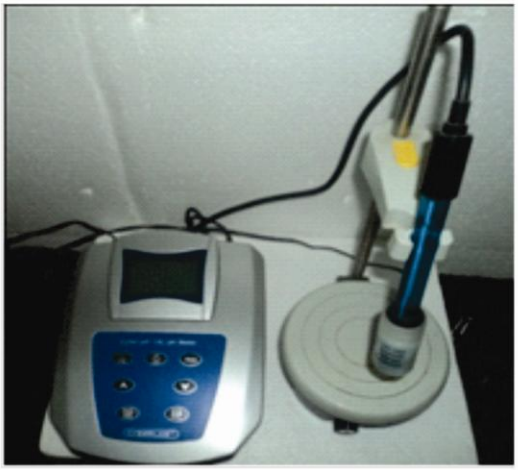

PLATE V
pH Meter

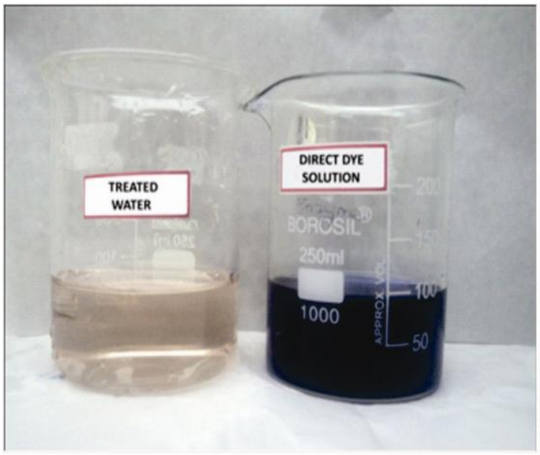

PLATE VI

Direct Dye Water and Treated Water

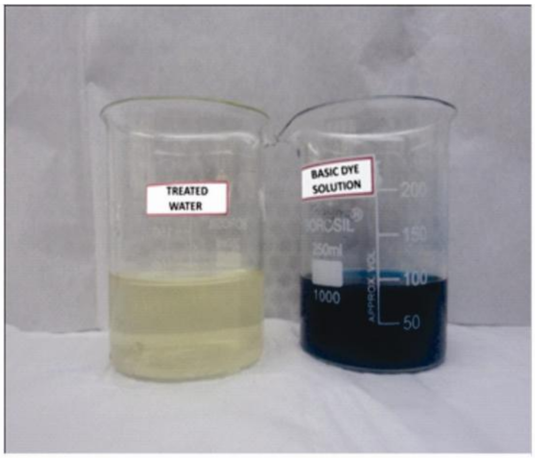

PLATE VII

Basic Dye Water and Treated Water

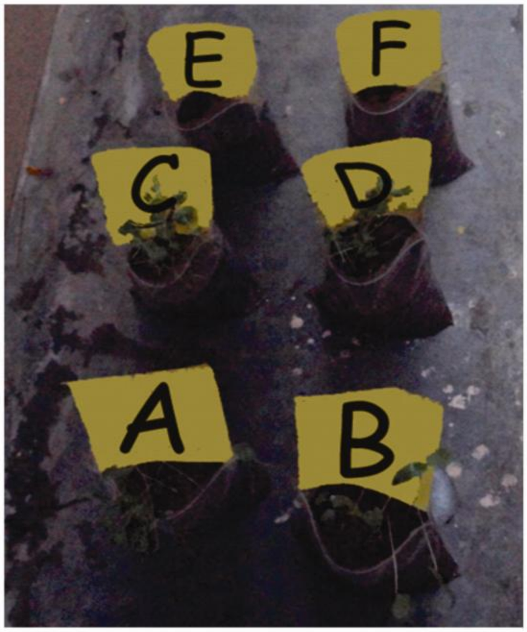

PLATE VIII

Plants on 7th Day

PLATE IX

Plants on 14th Day

PLATE X

Root length and Shoot length of Green gram Plant on 7th day

PLATE XI

Root length and Shoot length of Green peas Plant on 7th day

PLATE XII

Root length and Shoot length of Green gram Plant on 14th day

PLATE XIII

Root length and Shoot length of Green peas Plant on 14th day

PLATE XIV
Extracted Chlorophyll

PLATE XV
GSM Cutter

PLATE XVI
Thickness Guage

PLATE XVII
Stiffness Tester

PLATE XVIII
Drape Meter

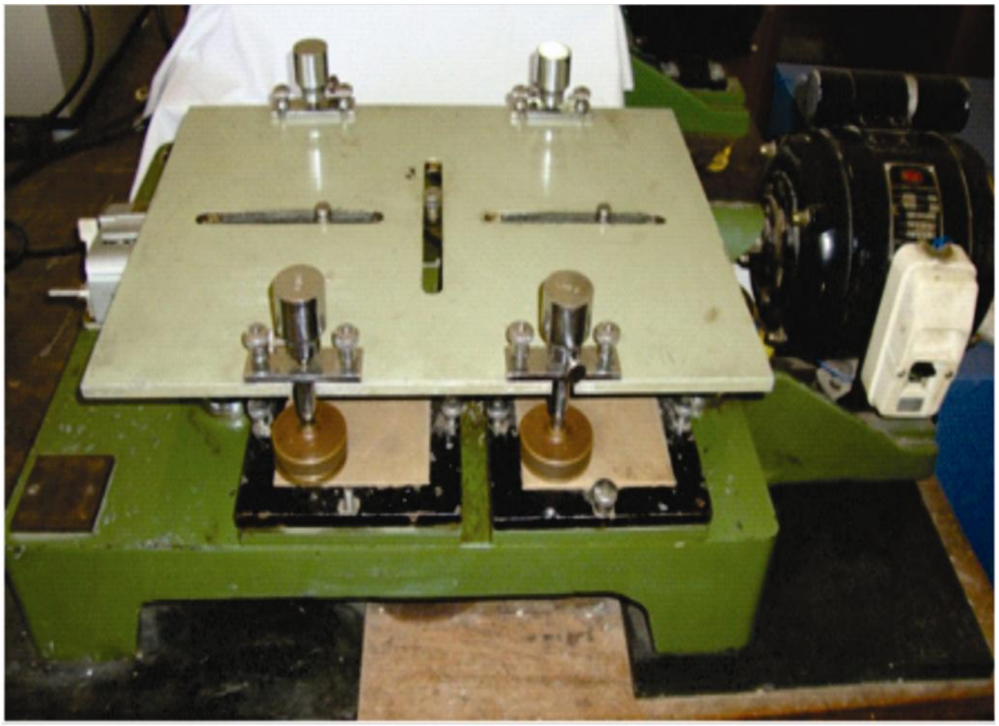

PLATE XIX
Abrasion Resistance Tester

Summary and conclusion

5. SUMMARY AND CONCLUSION

The various process used in the textile processing industry contributes color's major portion to the environmental pollution. About ten percent of the dyestuff used during the dyeing process does not bind to the fibers and therefore released into the effluent. The dye molecules are highly structured and hence, they are very difficult to breakdown. Of the entire waste, color is the first contaminant to be recognized because it is visible to the human eye. Waste water from some textile process houses are highly colored and concentrated containing strong organic wastes. The major problem of dye house waste water is the color that is produced by the residual dyes after the completion of dyeing process.

Different physical and chemical methods have been employed for the treatment of dye waste water. These methods mostly suffer from serious limitations, like high cost, low efficiency, limited versatility and production of secondary pollution. Among these treatment technologies, adsorption is the most promising option for the removal of non-biodegradable organics from aqueous effluents. The chemical composition and the hydration state of the soil play a major role in this adsorption. Different types of water soluble dyes can be effectively adsorbed on soil minerals. The use of soil in wastewater treatment has received increasing attention and currently offers a very attractive method for pollution remediation. Besides it is plentiful and inexpensive. Therefore an attempt has been made to experiment the decolorization of direct and basic dye solutions using soil with the following objectives.

- To assess the characteristics and pollution load of selected direct and basic dye solutions.
- To decolorize the selected dye solutions using river soil.
- To optimize various parameters such as dye concentration, soil concentration, time, pH and temperature on dye decolorization.
- To evaluate the effectiveness of dye treated water.
- To utilize the treated water for dyeing and irrigation purpose.
- To evaluate the growth of plants by biometric and biochemical analysis.
- To evaluate the dyed sample.

With the above objectives, a trial has been made to decolorize the direct and basic dye solutions. To decolorize the direct and basic dye solutions, soil was taken from Ashtamudi River, Kerala. For the study, the dye solutions of both direct and basic dye solutions were prepared by mixing 0.02 gm of direct dye in a hundred ml of water and mix well. Then four gms of river soil was added in it and kept for one day. In the similar way basic dye solution was prepared by mixing 0.01 gm of basic dye in a hundred ml of water and mix well. Then four gms of river soil was added in it and kept for one day. Various parameters like pH, temperature, dye concentration, soil concentration and time were optimized for effective decolorization of direct and basic dye solutions using river soil. The percentage of dye adsorption was estimated using UV- Visible spectrophotometer.

The best temperature for the decolorization of both the dyes was 30^0C. The best pHs for the decolorization of direct and basic dyes were 5 and 7 respectively. The pHs of the solutions were changed by using 1 normality HCl or 1 normality NaOH. The large scale production of decolorized water was prepared by taking, 0.6 gm of direct dye and 0.3 gm of basic dye in two different three litre vessels. Then 40 gm of river soil was added in that vessels and kept it for one day for decolorization. Then the decolorized direct and basic dye solutions were filtered by using muslin cloth and stored in clean beakers. Both the treated water were reused for dyeing the cotton fabric using direct dye and for assessing the growth characteristics of green gram and green peas plants. For dyeing, 174gm of cotton fabrics was desized and each 58 gm was used for dyeing. After desizing, the cotton fabric was dyed with direct dye. To dye the fabric; soft water, direct dye treated water and basic dye treated water were used. The soft water, direct and basic dye treated water dyed samples were evaluated by 25 PG students from Textile and Clothing Department. General appearance, brilliancy of shade and evenness of dyeing were taken into consideration for visual evaluation. These samples were taken for objective evaluation, like fabric weight, fabric thickness, fabric strength and evaluation, fabric stiffness, fabric drape, crease recovery, abrasion resistance, absorbency tests and color fastness tests were carried out. In all of these tests, both treated waters samples gave good results than the soft water samples.

Both the treated water were used for irrigation. Green gram and green peas seeds were selected for the study considering their nutritive importance and high consumption of Indian people. The seeds of green peas and green gram were sown in six covers marked as A to F containing red soil and sand. In which both cover A and C (green peas and green gram) were fed with tap water and cover B and D (green gram and green peas) were fed with direct dye treated solution and basic dye treated solution and the last covers E and F (green gram and green peas) were fed with pure solutions of direct and basic dye. Then the biometric parameters (vigor index, germination percentage) and biochemical parameters (total chlorophyll content, total carbohydrate content and total protein content) of these plants were checked. In all of these tests, the direct dye treated dye solution and basic dye treated solution samples showed good results than the soft water (control) plants.

FINDINGS

Optimizations of Decolorization

- The optimum direct and basic dye concentrations tolerated by river soil was found to be 0.02% and 0.01% respectively.
- Percent decolorization in direct and basic dyes was found to be maximum at a soil concentration of 4%.
- An incubation time of 24 hours resulted in maximum decolorization using river soil.
- The optimum pH for the decolorization of direct and basic dye solutions was found to be pH 5 and pH 7 respectively.
- The optimum temperature for decolorization of direct and basic dye solutions by river soil was noted to be 30^0C.

Utilization of Direct and Basic Dye Treated Water for Irrigation

- The green gram and green peas plant watered with direct dye treated water and basic dye treated water shown apparent growth against the control which had been watered with plain water.
- Germination percentage of the samples which was watered with direct and basic dye treated water was similar to control and vigor index of the samples have shown a

slight increment than control. Total chlorophyll, total protein and total carbohydrate of the samples were nearer to control.

Subjective and Objective Evaluation of Dyed Samples

- Fabric weight of the samples dyed using soft water and both direct and basic dye treated waters have increased to 0.02%, 0.05% and 0.04% respectively when compared over original. It may be due to the result of more dye uptake by the samples.
- Fabric thickness of soft water and both direct and basic dye treated waters have increased to 0.05%, 0.08% and 0.11% respectively when compared to original.
- Strength of dyed samples at both warp and weft directions were increased. Both direct dye treated water and basic dye treated water samples showed8.8%, 43% and 46% respectively in warp direction and 17%, 26% and 41% respectively in weft direction.
- With regard to elongation SDS, DDS and BDS samples showed increase along warp directions by 12%, 20% and 20% respectively.
- All dyed samples of SDS, DDS and BDS were increased in elongation of weft direction by 18%, 42% and 42% respectively.
- Dyeing were decreased stiffness when compared over original in along both warp and weft direction in all the samples.
- The dyed samples of SDS, DDS and BDS were showed decrease in abrasion resistance.
- SDS, DDS and BDS samples showed increased crease recovery by 5%, 4% and 4% respectively in warp direction when compared to original. In the case of weft direction DDS sample had no loss or gain over original where as SDS and BDS showed an increase of 2% and 1% in weft direction.
- Drape coefficient were increased in SDS, DDS and BDS samples.
- Absorbency nature of samples was found to be increased after dyeing the samples with direct dye and basic dye treated water.
- Samples subjected to color fastness test exhibited excellent fastness properties. Fastness to light, wet pressing, wet crocking were ranked as good by scoring 4 for SDS,DDS and BDS. Fastness to dry pressing and dry crocking were ranked as excellent by scoring 5 for DDS and BDS samples and good by scoring 4 for SDS samples.

CONCLUSION

"Earth can cater to every need of man" is proved by this research, where in soil is used to remove the color left back in water after dyeing. The result also throws light on usage of decolorized water for agriculture and redyeing. The results also extend a warm helping hand to dyeing units which dump the colored water into river and increase water pollution. In a nutshell the research is a timely work for the call of "Save the Earth", Go Green"!!!

SUGGESTIONS

- Research could be carried out using effluent containing dyes other than direct and basic.
- The effectiveness of chemically treated soil could be tried for decolorization of dye effluent.
- Fungi and bacteria could be isolated from the soil for decolorization of dye effluent.

LIMITATIONS

- It cannot be used for disperse dye.

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Appendices

APPENDIX I

Grey Scale Used to Evaluate the Dyed Samples.

The dyed samples were evaluated by using the AATCC (American Association of Textiles Colourists and Chemicals) grey scale to measure the extent of colour change and staining. The grey ratings envisaged the following standards for colour fastness to reactive dyed samples using soft water and treated water.

Grey Scale Rating	**Colour Change**
5	No change (Excellent)
4	Slight change (Good)
3	Noticeable change (Fair)
2	Considerable change (Poor)
1	Much change (Very poor)

APPENDIX II

Original and Dyed Fabric Samples

Fabric - Cotton
Weave – Plain Weave

(SDS)
Soft Water Dyed Sample
Fabric - Cotton
Weave – Plain Weave
Dye Used – Direct Dye

(DDS)
Direct Dye Treated Water Dyed Sample
Fabric - Cotton
Weave - Plain Weave
Dye Used – Direct Dye

(BDS)
Basic Dye Treated Water Dyed Sample
Fabric – Cotton
Weave – Plain Weave
Dye Used- Direct Dye