**REUSE OF DECOLORIZED WASTEWATER IN TEXTILE WASHING PROCESS**

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### DEDICATION

We dedicate this thesis to our beloved parents. Their endless love, affection, support, encouragement and prayers have always been a source of inspiration and a key role in our way to success*.*

**CERTIFICATE OF APPROVAL**

#### It is certified that this thesis is based on the results of work done by Nimra Shahbaz, Maryam Fatima and Zainab Amjad. We certify that all the data and results reported in the thesis are correct and authentic. We fulfilled all the condition of University of the Punjab for the submission of this thesis. This thesis is hereby approved for submission to the University of the Punjab, Lahore for the partial fulfillment of the requirement for the degree of BS in Environmental Sciences.

**PRINCIPAL SUPERVISOR**

# ABSTRACT

#### The purpose of conducting the research was to remove dyes from textile wastewater by using electrocoagulation process. It is the wastewater reuse approach; the study was carried out on two reactive dyes i.e. C.I. Reactive Red 221 and C.I. Reactive Yellow 145. Wastewater was prepared in the laboratory and then treated and reused.The technique used for this purpose was electrocoagulation technique. Dyes of concentration 1%, 3%, 5% were studied for C.I Reactive Red 221 and C.I Reactive Yellow 145. pH was controlled and standard wastewater was maintained at three pH levels (4, 7 and 10). After isothermal dyeing, the dyed fabric was shifted to conventional wash-off process. The water resulted in the dyeing wash-off process duration was treated by electrocoagulation technique and further it was reused in next washing process of dyeing.

#### Electrocoagulation treatment method proves highly effective in color removal of textile wastewater. The best results were observed of 1% shade of C.I. Reactive Red 221 that was 98% in a time duration of 15-20 minutes. For C.I. Reactive Yellow 145, the removal efficiency was 96% after time interval of 20 minutes of 1% shade.

#### The removal of reactive dyes was extremely affected with the change in pH. pH has significant effect on electrocoagulation’s efficiency treatment method to remove dyes from dyeing wastewater. The effect of pH 4 on Electrocoagulation efficiency resulted least color removal that was below 84%. When pH reaches to maximum alkaline level, the excellent removal efficiency was achieved. It was indicated that when pH varied from 7 to 10 of dyeing wastewater, the removal efficiency was increased.

#### Color measurements were also observed for both reactive dyes. Results of color measurement showed that color difference values of Sample C (fabric treated by pH 10 wash-off) were found to be within the acceptable range that were from 0.38 to 1.50 of all dyes and shades (5%,3%,1%) because the best removal efficiency of dyes were observed in alkaline pH. Sample A having pH 4 of all the dyes has a large color difference and shows quite large CMC values. Sample A values were found between 2.44 to 13.48 that were not within acceptable limit i.e. ≤ 1. Sample B (fabric treated by pH 7 wash-off) values were found to be intermediate as compared to Sample A and Sample C.

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#### Nimra Shahbaz

#### Maryam Fatima

#### Zainab Amjad

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# LIST OF ABBREVIATIONS

|  |  |
| --- | --- |
| **IPCC** | Integrated pollution Prevention and Control Directive |
| **IED** | Industrial Emission Directive |
| **COD** | Chemical Oxygen Demand |
| **DC** | Direct Current |
| **GSM** | Grams Per Square Meter |
| **UV-Vis** | Ultraviolet-Visible |
| **RB5** | Reactive Black 5 |
| **CR** | Congo Red |
| **WRF** | Water Rot Fungi |
| **RBBR** | Remazol Brilliant Blue Removal |
| **LE** | Liquid Extract |
| **RPM** | Revolutions Per Minute |
| **Ph** | Power of Hydrogen |
| **CW** | Coffee Waste |
| **EC** | Electro Coagulation |

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# CHAPTER 1

# INTRODUCTION:

#### Water pollution is a global issue that requires consideration. The water resources decreased by drought and population growth have pledged authorities to manage water resources. Water contamination is primarily resulted by the dramatic effect of industrialization (Rasmi Patnaik et al., 2017).

#### Annually, many people lost their life and millions of us are at risk. Achieving clean water and sanitation have become crucial elements for developing countries.Water pollution accounts for third highest risk factor for disease and disability (Gibson J.M. 2019). It demands frontal attack to eliminate these diseases.

#### Industrialization changes the human life from an urban society to developed one by social and economic revolution. It is a huge transformation method where technological modernization leads to high economic growth. It removes the barriers to success but have some adverse effect on environment. Most of the industries are implemented near to rivers, streams or water bodies thus creating a way to water pollution. Industries dispose tons of waste products into nearby water bodies. Therefore, sustainability demands different ways to minimize the water pollution caused by industries. The manufacturers should think about the water management. Over the past few decades, a policy has been established to reduce water pollution. The most important directive for industries is the presence of the Integrated Pollution Prevention and Control Directive (IPCC) rescindment the Industrial Emissions Directive (IED) and the Water Framework Directive (Evrard et al., 2016).

#### The textile industry is the leading industry in many countries in the world. A textile industry needs to reuse the water due to high water consumption in washing and dyeing process. Globally, one in three people do not have access to clean water. Shortage of water and growing demands of clean water, urge textile industries to treat water. Being an expressive consumer of water, textile dyeing is carried out in different aqueous baths and yields polluted wastewater. Wastewater from textile industry comprises of different dyes and chemical additives, as some are difficult to degrade.

#### The potential contaminants of textile wastewater are non-biodegradable organic and inorganic compounds such as metals, phenols, color, pesticides, phosphates and certain surfactants. This contaminated textile wastewater is not only dreadful for humans but also for aquatic life as aquatic life cannot survive in polluted media. The suspended solids present in polluted water clogs in fish’s gills resulting in retarded growth and often leads to death. Therefore, the search for an effective treatment method for treating textile wastewater is essential. Various techniques have been used for wastewater treatment based on biological, physical and chemical processes. Wastewater from textile industry shows high coloration and low biodegradability, hence making it difficult to treat with physical, chemical and biological treatment methods.

**Table 1.1 Techniques Used in Wastewater Treatment**

|  |  |  |  |
| --- | --- | --- | --- |
| Techniques Name | Dye Removal Efficiency | Drawbacks | References |
| Chemical Coagulation | 44.5% | **High variance of water composition****Difficult to process multiple contaminants at once****It is an additive process****High operational costs** | Verma et al., 2012 |
| Advanced Oxidation | 98% | Relatively high capital and operating costsRemoval of residual peroxide may need to be consideredComplex chemistry tailored to specific contaminants | Azbar et al., 2014 |
| Wetlands | 94% | Land take is highLittle reduction in run volumeRequires base flowLimited depth range for flow attenuation | Olejnik,D.,& Wojciechowski, K. (2012). |

#### Generally conventional biological treatment methods are efficient for high chemical oxygen demand COD, but low efficiencies in discoloration are observed due to the chemical stability and resistance to microbiological attack of the dyes (Bes Pia et al.,2005). Chemical coagulation can completely remove the color of dyes but limited due to additional treatment for its massive sludge. Advanced oxidation processes have emerged as an effective water treatment method for oxidizing various organic pollutants, including those that cannot be treated with conventional techniques but form complex structure with reactive dyes (Oller.I. et al., 2011). Wetlands are built up for wastewater treatment but are not effective in color removal and require large area. Electro coagulation is acting as a problem solver in treating textile industry wastewater.

#### Restricted water consumption, source reduction and treatment have become crucial factors for sustaining water. Among the major environmental concerns removal of dyes from textile wastewater is the one because it has been reported that only 87% of its content can be decomposed (Pagga, U. et al., 1986). The important problem of waste from textile industry is the color of dyes obtained from textile industry (Willmott, N.J. et al., 1998).The primary reason color appearance in the textile wastewater is due to the use of excessive amounts of reactive and vat dyes. Commonly, reactive dyes are used for dyeing cellulose fibers as more than 50% of cotton products are colored with reactive dyes. In wastewater more than 15% dyes are introduced in streams during the dyeing process. A better way is to try to regenerate the wastewater dye for reuse.

#### Reusing textile wastewater after decolonization is essential for large water utilization in textile industry. Textile wastewater can be reuse in its decolorized form. For treating textile wastewater, a technique that is cost effective with efficient color removal is required. Electro coagulation is a diversified treatment technology that deals with wide range of contaminants. It removes total suspended solids (TSS), heavy metals, emulsified oils, bacteria and all above color from wastewater. Textile wastewater is treated with electrocoagulation process as it is a convenient and less expensive way to recycle water. After recycling, water can be reuse in the dyeing process as it is decolorized now. Recycling by electrocoagulation method not only reduce the pollution level but also lowers the consumption of fresh water. Reusing will ultimately ends up zero or less water discharge. Electrocoagulation caused the pH to normally shift toward the neutral and minimum time is required for suspended solids to settle down. Electrocoagulation is more efficient as compared to other techniques as it removes even the fine particles or impurities from water. Therefore, the sample can be reused with an electromotive force that causes the chemical reaction in wastewater. It triggers the forces and bonds of dyes and removes the color from dyes. Decolorized water can further be used safely in textile industry.

## 1.1 Aims and Objectives:

#### The objectives of this research are as follows:

#### To initiate a method for decolorizing liquid in the wash off process.

#### To compare the quality of dyeing in overall color difference of coagulant treated fabric with respect to conventionally washed fabrics.

#### To study the effects of process parameters on the decolorization of electro coagulation process for different reactive dyes.

## 1.2 Textile Industry Process

#### There is a wide range of machinery and procedures involved that plays a vital role in the formation of required shape and final product. A large amount of effluents is released during various steps such as sizing, de-sizing, bleaching, scouring and mercerization. They are generated during dyeing; printing and finishing. The composition of such effluents mainly involves dye residues, salts, acids, bases, various chemical agents, and byproducts. Various salts were obtained as a byproduct such as Sodium Chloride (NaCl) and Sodium Sulphate (Na2SO4) in the neutralization during wet processing in textile industry.

**Table 1.2 Textile Industry Process**

| Process | Composition of Effluent | Parameters (BOD/COD/TSS/DS/Heavy Metals) |
| --- | --- | --- |
| Sizing | Starch, waxes, wetting agents, Poly vinyl alcohol, Carboxy methyl Cellulose. | High in BOD, COD. |
| De-sizing | Starch, CMC, PVA, fats waxes, pectin. | High in BOD, COD, TSS, DS, SS. |
| Bleaching | Chlorides, sodium hydroxide, hydrogen peroxide, acids, surfactants, sodium phosphate, sodium silicate, short cotton fabric. | High alkalinity, high SS. |
| Mercerizing | Sodium hydroxide, cotton wax. | High pH, low BOD, high DS. |
| Dyeing | Dyestuff, urea, reducing agents, oxidizing agents, Acetic acid, detergents, wetting agents. | Strongly colored, high BOD, DS, low SS, heavy metals. |
| Printing | Pastes, urea, starches, gums, oils, binders, acids, thickeners, cross linkers, reducing agents, alkali. | High dye concentration, high BOD, oily appearance, SS, slightly alkaline. |

## 1.3 General Methods Used for Wastewater Treatment

#### There are various methods for the treatment of wastewater. These treatments have been divided into three main categories named as physical chemical and biological methods.

#### There are many conventional methods that are used to treat the textile wastewater. These methods include physical, physiochemical or biological method. Because textile wastewater has variability in their composition so these conventional methods are not sufficient or adequate to remove all organic or inorganic matter from the water. It is essential for every industry to release their effluent in less toxic form to achieve quality of specified standards. The cost of treating the textile wastewater is rapidly increasing in recent years.

#### Chemicals release from the industries has complex structure so they require specific handling in removing them. Due to increasing demand of treated water industries requires simple, efficient and cost-effective treatment method. It should manageable in less space and chemical consumption to avoid secondary pollutant production. Electro coagulation is electrochemical process that removes pollutants without any additional chemical and proved to be cost effective.

**Table 1.3 Various Methods Used for the Treatment of Wastewater**

| Physical Methods | Chemical Methods | Biological Methods |
| --- | --- | --- |
| Sedimentation | Neutralization | Stabilization |
| Filtration | Oxidation | Aerated lagoons |
| Floatation | Reduction | Trickling filters |
| Foam fractionation | Catalysis | Activated sludge |
| Coagulation | Ion exchange | Anaerobic digestion |
| Reverse osmosis | Electrolysis | Fungal treatment |

# 

## 1.4 Electro Coagulation Process

#### The Electro coagulation is a process of wastewater treatment in which all solids (suspended, colloidal and dissolved), metals and dyes from the wastewater are treated. Electro coagulation process helps to remove the pesticides, pollutants and harmful micro-organisms from the water. Electrocoagulation process comprises of two electrodes of iron or aluminum that are dispersed in treating water. Direct Current is used as a source of power supply. When Electrocoagulation process is operated, it dissolves the metal ions from the electrode in the aqueous media. The metal hydroxide produced at suitable pH are insoluble in water hence can be removed. As additional chemicals are not required, secondary pollutant will not produce. Electrocoagulation produces less sludge .

#### Electrocoagulation process is preferred over physiochemical or biological method due to its simple process design. Electrocoagulation treatment is cost effective approach to a healthy environment. Organic and inorganic content is removed from wastewater to protect the environment. Use of two reactive dyes that are red 221 and yellow 145 at pH 4, 7 and 10 are used, analysis revealed that at high alkaline medium which is pH 10 the electro coagulation technique showed excellent results.

## 1.5 Dyes and Its types

#### The dye is distributed into the fibers of the cotton or fabric by introducing chemical, absorptive technique or through the process of diffusion. Dyes are reluctant in nature and resistant to many agents. It depends on their similarity with different fibers and their reaction to detergents and solubility.

#### There are two types of synthetic and natural dyes. Synthetic molds are artificial dyes that are categorized according to their chemical composition and usage during dyeing. In contrast, natural dyes distributed three main types, natural dyes that are obtained from flora called indigo and the other that are obtained from fauna are called cochineal. Dyes that are obtained from reserves are called meteorites.

#### 1.5.1 Alkaline Dyes

#### This is the first synthetic dye extracted from the derivatives of coal tar. They are used for printing and for making leather, paper, wood and straw. Recently they have been effectively used in some ready-made yarns, particularly acrylics.

#### 1.5.2 Direct Dyes

#### The anionic dyes are easily soluble in aqueous solution in the presence of electrolytes. These dyes have great bonding to cellulose fibers. They are mainly used in the dyeing of cotton and regenerated cellulose, paper, leather and to lesser extent nylon. Majority of the dyes in this class are poly azo compounds. To increase wash fastness, frequently chelations with metal salts are introduced to the different type of dyes.

#### Direct dyes are basic dyes that are widely used because they do not require the additional use of mordant or binders in dyeing cotton.

#### 1.5.3 Acid Dyestuff

#### Acid dyestuff is diverse and an essential group of dyes. Although, it is mainly formed by the combination of acidic substances rather alkaline dyes originates from the natural organic base.

#### 1.5.4 Premetallized Dyes

#### Premetallized dye is an acid dye. It has complex metal ions for improving its fixing to wool and nylon groups in the presence of light.

#### 1.5.5 Sulfur Dyes

#### Sulfur dyes provide are darker in shades but are resistant to solar radiations. These dyes are used both for cotton and rayon fabric, but are less bright. Use of Sulfur dyes causes problem as they make the fabrics less strengthen and change in its structure. Therefore, sulfur dyed fabric must usually be treated with a base to neutralize the acid that has been formed.

#### 1.5.6 Azo Dyes

#### These colored dyes are mainly used in bright red tones for dyeing and screening purpose, because some other types of fast dyes lack good red dyes color. In industry they are said to be Naphthol Azo dyes.

#### 1.5.7 Vat Dyes

#### These are probably the most widely used dyes because they have comprehensive wash ability and fastness in daylight for cotton and rayon fabrics. The word vat has been originated from old indigo dyeing process: Indigo must be restored to light color. They are successfully used for all kinds of fabrics.

#### 1.5.8 Chemical Fiber Dyes

#### Manmade dyeing fibers such as cellulose acetate, poly acid, Polyester and Acrylic have proved to be a great task for dye users. Each new fiber must be carefully examined and verified for its response to by taking different dyes, when obtained from the laboratory. This process has been continuously tested and new developments have continued.

#### 1.5.9 Alizarin Dyes

#### These are vegetable dyes, originally from alfalfa plants. They are used for various types of fabrics. In addition to other colors, they also produced brilliant Turkey Red.

#### 1.5.10 Chromium Dyes

#### These are special type of dyes to dye wool and the worsted fabrics from animal fibers. They react easily with metals that are present on fabric such as chromium. When fabric is dyed with this process they make color dull, but it gives more light fastness and the washable fastness.

#### 1.5.11 Neutral Dyes

#### Neutral dyes are acid dyes that include metals. At the time of manufacturing neutral dyes, the metals are added in it. These are metal-containing acid dyes, and metal is added at the time of manufacturing.

**Table 1.6.1 Properties of C.I Reactive Red 221**

|  |  |
| --- | --- |
| **Dye** | **C.I. Reactive Red 221** |
| **Molecular Structure** | **C.I.Reactive Red 221,CAS 96726-27-1,1699.34,C57H35N16Na6O24S6,Reactive Red R-3B** |
| **Molecular Formula** | C57H35N16Na6O24S6 |
| **Molecular Weight** | 1699.34 g/mol |
| **Solubility** | Soluble in water |
| **Maximum Wavelength** | 520nm |

**Table 1.6.2 Properties of C.I Reactive Yellow 145**

|  |  |
| --- | --- |
| **Dye** | **C.I. Reactive Yellow 145** |
| **Molecular Structure** | C.I.Reactive Yellow 145,CAS 93050-80-7,1026.25,C28H20ClN9Na4O16S5,Reactive Yellow 3RS,Reactive Yellow M3RE,Reactive Yellow ME-3RS,Reactive Yellow SP-3R |
| **Molecular Formula** | C28H20ClN9Na4O16S5 |
| **Molecular Weight** | 1026.25 |
| **Solubility** | Water Soluble |
| **Wavelength** | 419nm |

# CHAPTER 2

# LITERATURE REVIEW:

#### Textile industry wastewater is composed of complex components that includes synthetic dyes, dispersants, bases, acids, detergents, salts, surfactants, grease, and oil, (Pelosi et al., 2014). Dye effluent released from textile industry has chemicals and other toxic substances which cause carcinogenicity, mutagenicity. Different treatment methods were used to remove dyes from textile wastewater such as chemical oxidation, biological treatments, electrochemical and physical methods.

#### Reactive dye wastewater is water-colored, with high concentrations of salt and high values of COD and TOC. When this wastewater gets contaminated with water bodies, degrades water quality progressively. Various treatment methods are used to remove dye color for reuse purposes. To study these techniques and methodologies and their significance in removal of such effluents that acts as triggering force in water reuse, fifteen papers have been studied and reviewed.

#### The water consumption in wet processes is higher than other processes such as spinning and weaving. Textile industry requires a large quantity of water as all dyeing and finishing processes are operating in water bath hence. Textile industry generates millions of gallons of dye wastewater daily (Shaikh, 2009). Study conducted to reuse the industrial wastewater after electrochemical treatment of textile effluents without external addition of chloride was studied for effluents removal; dye from textile industry. Reactive dyes are mainly used for dyeing cotton in textile industry. It is estimated that these industries have used over 100,000 different dyes resulting the production of 700,000 tons per year (A. S. Arun Prasad., et al 2010).

#### The study reported that the reuse of decolorized water after treatment of electrochemical method can be possible in dyeing process. Researchers used four consecutive dyes for this purpose and compared the color variation with simple water and treated water. All other parameters including TOC, COD AOC were also studied. Results evaluated revealed that treating through electrochemical method provide water that can be reused in industry. The results of color similiarity DECMC (2:1) in the dyed fabrics in the four reuses are less than the maximum limit of acceptance of color differences in the textile industry that is one unit (DECMC (2:1) ≤ 1 ( F. Orts et al., 2019).

#### Most common dyes are used during dyeing process that are classified according to their chemical nature i.e. reactive dyes, acidic dyes and dispersed dyes. (Phalakornkule et al., 2010). Acidic dyes have been used for nylon, acrylics and woolen blend. The dye molecules contain aromatic rings which are refractory to the traditional treatments of degradation and elimination. (Orts F. et al., 2019). Wastewater released from the textile industries can contain upto 200 mg/L of dye and a mixture of other organic and inorganic chemicals and additives ( Jamee.R , Siddique.R, 2019).

#### An alternative technique is advanced oxidation rather than conventional treatment methods for the degradation of industrial waste effluents and organic compounds present in it. Advanced oxidation process produces reactive and oxidizing free radicals that have much higher oxidizing ability. In this oxidation process, no additional chemicals added and less sludge is produced as compared to the conventional biological method. But require expensive reagents and high energy resources such as ultraviolet radiations (Azbar, et al., 2004).

#### A study was carried out for the treatment of synthetic wastewater containing azo dyes found in textile industry wastewater by anaerobic biological method and chemical oxidation. In the microbial process, a sample process was performed. The results clearly experienced that by increasing the residence time, yeast extract and the addition of microorganisms had positive effects on the dye removal (A.B. Dos Santos., et al., 2006). In the microbial process, parameters such as the wastewater composition, the residence time, yeast extract’s amount, wastewater flow rate and the addition of microorganisms from wood chips were investigated. The highest removal obtained by the microbial process was approximately 89%.

#### Rather microbial process is an environmental friendly process but the treatment demands longer time to ensure the adaptation of microorganisms adaptation. Hence, Electrocoagulation being a fast process, was proven to be a very effective method for the decolorization of textile dyes and to attain maximum percentage removal capacity. From economic perspective, the use of microorganisms for synthetic dyes is reliable due to cost effectiveness.

#### Bioremediation is an environment-friendly and an effective alternative to conventional methods for the treatment of textile wastewater ( Jamee . R, Siddique . R, 2019). Decolorization of textile wastewater by bacterial consortium, few reports is available on decolorization of dyes by yeast consortia and fungal consortia, especially on decolorization by biodegradation mechanism not by biosorption or bioaugmentation (Sghaeir I. et al., 2019).Bacterial degradation is used for the degradation of synthetic dyes. Decolourization of dyes under anoxic, aerobic and anaerobic conditions was studied. Microbial degradation generates byproducts that are much more toxic. Microbial degradation of azo dyes produces organic compounds and aromatic amines that are concerned as mutagens and carcinogens (Sghaeir I. et al., 2019).

#### The process of Adsorption is also used for treatment of textile wastewater. Dye industry is known as the tenth most polluting industry to river’s water, as about 17–20% of the industrial water pollution is contributed by the textile treatment and process. Removal of anionic textile dyes is an effective method by using adsorbent synthesized coffee waste was studied. For adsorbent synthesis coffee waste is most suitable due to high consumption of coffee by consumers. Researchers removed two dye colors for this research, Congo red and Reactive Black 5.

#### Study investigated contact time, temperature, solution pH, adsorbant dose and dyes adsorption into coffee waste. The high pH value indicates the maximum adsorption of dye that was 8.57. The structure of CW is typically three-dimensional carbon structure having rough surface. Contact time of Sample adsorption was observed. Findings revealed that the maximum adsorption contact time for RB5 was 50 minutes and CR was 106 minutes. Percentage Removal evaluated 86% and 99% CR and RB5 respectively. The kinetic evaluation was carried out by setting the experimental data to the pseudo-first-order (PFO) and pseudo-second-order (PSO) kinetic models. Finding reveals that the adsorption of RB5 and CR dyes onto coffee waste is controlled by process of chemisorption (Wong S. et al., 2020).

#### A study was conducted to remove the indigo carmine dye that is used in industrial denim dyeing processes. For this purpose, an integrated advanced oxidation process was used by combining electrocoagulation.(M. A. García, Morales, et al., 2013). Effluents containing dye’s effluents could prevent light from penetrating into lagoons, rivers, or lakes, inhibiting biological processes based on photosynthesis. Furthermore, these effluents can contain chemicals that are more toxic, carcinogenic, mutagenic or teratogenic in case of many microbiological or animal species.

#### The kinetics of the reaction for decolorization and turbidity in the ozone-electrocoagulation process indicated that the accuracy obtained in the integrated process depend on the ozone and electrocoagulation treatments.(Morales, G. et al., 2003) As a result of this treatment, the low intensity spectrum between the untreated wastewater and the treated wastewater indicates oxidation by removal of the organic compound in the process. This result was consistent with the cyclic voltammograms resulted as ozonation was attractive for wastewater treatment because ozone was soluble in water and could rapidly degrade in the form of free radicals reacting with any organic compound such as dyes. The entire research reported that both processes (ozone and electrocoagulation) were combined in Sample reactors to increase the decolorization efficiency of denim dyeing compared to a single treatment.

#### Ionization radiation is a well known technique for decolorization of textile water. The radiation technology methods normally uses a strong oxidizing species (OH radicals) that have high electrochemical oxidation potential and cause a sequence of reactions for breakdown of the macromolecules of dye into smaller and less harmful substances (A.N.M. Bagyo et al., 2001). High energy radiations are produced that can transform energy from accelerated electrons to orbital electrons. Absorbed energy not only disturbs the electron system of the molecule but also cause the interatomic bonds breakage. This breakage results the ionization of water molecules into H2O+.

#### Textile wastewater is decolourized by gamma radiation and reusing treated water in dyeing revealed the possibility of reusing textile wastewater in dyeing cotton fabric after decolorization that will ultimately reduce the wastewater generation and consumption of wastewater. Sample of wastewater were collected and four different radiation doses (3kGy, 5kGy, 8kGy, 12 kGy) were provided without any dilution. The electromagnetic radiations were emitted from Cobalt 60. Color removal efficiency and pH of wastewater and irradiated water were analyzed and compared. The pH value was decreased from 9 to 7- 7.5 near to neutral, whereas the pH reduction for each dose was also observed. The color reduction percentage increased with the increase of increment of radiation dose. High color removal was observed at high dose. Results indicated that it would be a satisfactory method in reusing textile wastewater.

#### Study conducted by (J.A.Chicatto et al., 2017) revealed that by decolorizing textile industry wastewater in solid state by fermentation with peach palm (Bactrius gasipaes) residue. Wastewater is decolorized in two processes, by Water Rot Fungi (WRF) and adsorption of dyes through solid matrix by using the residue of peach palm. White rot fungi (WRF) are known for their ability to degrade lignin and a huge amount of xenobiotic pollutants that are found in soil and water by accumulation, including dyes, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, explosives, and pesticides (Asgher et al., 2012).

#### Ganoderma lucidum is among the most widely used Water Root Fungi in the world. Several studies conducted on G. lucidum primarily focus on its laccase-producing capacity and its feasability for the degradation of dyes and organic compounds (Rivera-Hoyos et al., 2015; Kuhar et al., 2015; Zhou et al., 2012). Wastewaters were provided from a textile industry that was used in processes of cellulose textile fibers, residual dye bath effluent and wastewater effluent. The peach palm sheath that was used in this work was an agro-industrial waste, produced from palm tree extraction and dried at 60 °C for 24 hours prior to use. After 14 days of processing, the content of the flasks was homogenized and a liquid extract (LE) was prepared by mixing 8 g of sample with 50 mL of distilled water. Solids present in the wastewater were then separated from the LE by vacuum filtration followed by centrifugation for 15 min at 4 °C (5,000 rpm). Then this was furthur used in process of adsorption. The highest decolorization values 76% and 73% were obtained from solid state fermentation by using 60 mL of the final effluent and 10 grams of peach palm sheath.

#### Above study provided innovative initiatives for upgrading the decolorization of textile dye using white-rot fungi and peach palm sheaths. The peach palm sheath functioned well in solid-state fermentation by developing fungal hyphae and producing oxidative enzymes. Results suggests that palm sheaths have remarkable potential in the process of Remazol Brilliant Blue Removal RBBR dye removal by degradation tusing G. lucidum enzymes.

#### Removal of reactive Dyes was studied by Amour et al., (2015) and resulted that results can be acheieved from textile wastewater by continuous electro-coagulation process. The concerned parameters in the study were current density, inlet flow rate, conductivity. The dye concentration observed was below 300mg/l with the residence time of 35 minutes. By using these parameters, the best results were achieved at 90% for turbidity and 97% for color removal. The Electrocoagulation process was suggested to be quite effective and much more reliable process.

#### Charoenarlp and Choyphan studied the efficiency of electro coagulation in Sample mode. Electrocoagulation was used for the treatment of this wastewater. After treatment color removal or variations were evaluated. Researchers carried out t Test to analyze the mean of water quality between water normally used or reused water. All other parameters conductivity, turbidity, suspended solids and water hardness were studied. Electrocoagulation is the most effective techniques in removing color and organic pollutants from wastewater (K. Charoenarlp and W. Choyphan , 2017).

#### From few decades, highly demanding method for treating colorized wastewater generated from textile industry is electrocoagulation due to its cost effectiveness and high efficiency. Electrocoagulation is highly efficient treatment method with respect to environmental compatibility, energy and cost requirement without chemical addition and reduces the reactive retention time. Electrocoagulation process is used over physiochemical or any other biological method due to its unique process design. The material that is used in Electrocoagulation treatment is budget freindly. Organic and inorganic content is removed from wastewater to protect the environment.

# CHAPTER 3

# MATERIALS AND METHODS

This chapter describes the materials, experimental set up and analytical methods used in this research work.

## 3.1 Materials:

Materials used in this study include fabric, chemicals, dyes and laboratory equipment.

#### 3.1.1 Fabric:

100% pure knitted, bleached cotton fabric having 200 GSM (Grams per square meter) was used in this study.

#### 3.3.2 Dyes:

Reactive dyes were selected because of their application in textile (cotton) dyeing. They are easy to use and show excellent fastness properties. The dyes used in this study were Red 221 and Yellow 145.

#### 3.1.3 Chemicals:

Chemicals like sodium carbonate (Na2CO3) and sodium chloride (NaCl) were used as exhaustion and fixation agents respectively. Acetic Acid (CH3COOH) is used for neutralization in wash-off process.

#### 3.1.5 Soaping agent:

Soaping agent is used in soaping step.

## 

## 3.2 Equipment and Instruments

#### 3.2.1 UV/ Visible Spectrophotometer:

The ultraviolet-visible (UV-Vis) spectrophotometer is an instrument usually used in the laboratory to study compounds using visible spectrum of ultra violet light. Decolorization was assessed in terms of absorbance using Visible spectrophotometer; Model 721, China.

The spectrophotometer was set at blank by taking distilled water in cuboid prior to actual reading.

#### 3.2.2 Portable Digital pH meter:

A portable digital pH meter was used for pH measurement at different treatment steps.

#### 3.2.3 Weighing Balance:

A Weighing balance was used to weight the materials.

#### 3.2.4 Digital Thermometer:

Digital thermometer was used to measure the temperature of the dye bath.

#### 3.2.5 Thermostatic Water Bath:

Laboratory scale water bath was used with a temperature range from 0-100 degree Celsius. This water bath was used to heat up the dyeing container at required temperature.

#### 3.2.6 Glass Stirrer:

A glass stirrer was used during the experiment to stirrer the cotton fabric in the dyeing process.

#### 3.2.7 - 5% Dyeing Depth Shade

For 5% dye, 50 ml water, 0.25g Reactive dye, 1g Na2CO and 4g NaCl were taken in a beaker. Then, dipped the fabric in the solution and put it in the water bath. After 20 minutes, add 4g of NaCl and after 10 minutes, add 1g of Na2CO3 in the dyeing solution when temperature was 60-70oC and stirred the sample for 45 minutes. The liquor ratio used for dyeing was 1:10.

#### 3.2.8 - 3% Dyeing Depth Shade

For 3% dye, 50 ml water, 0.15g Reactive dye, 1g Na2CO3 and 4g NaCl were taken in a beaker. Then, dipped the fabric in the solution and put it in the water bath. After 20 minutes, add 4g of NaCl and after 10 minutes, add 1g of Na2CO3 in the dyeing solution when temperature was 60-70oC and stirred the sample for 45 minutes. The liquor ratio used for dyeing was 1:10.

#### 3.2.9 - 1% Dyeing Depth Shade

For 1% dye, 50 ml water, 0.05g Reactive dye, 1g Na2CO3 and 4gNaCl were taken in a beaker. Then, dipped the fabric in the solution and put it in the water bath. After 20 minutes, add 4g of NaCl and after 10 minutes, add 1g of Na2CO3 in the dyeing solution when temperature was 60-70oC and stirred the sample for 45 minutes. The liquor ratio used for dyeing was 1:10.

## 

## 3.3 Description of Method

Samples of wastewater were all prepared in Industrial Wastewater Lab located at CEES, University of the Punjab, Lahore. In this study, three different dyes i: e; Red221 and Yellow 145 were used.

The 1% stock solution for dyeing was prepared by adding 10 g of Red 221, Yellow 145 and Blue 19 to a 1000 ml flask one by one and made them up to the mark by using distilled water. For both dyes, 25 ml of stock solution and 50 ml of water was added in the beaker to make the volume up to 75 ml. The beaker was then placed in a water bath of 60°C.

4g of salt and 5g fabric were added in the solution and mixed. As soon as the temperature reached 60°C, 1g of Na2CO3 was added to the solution while being continuously stirred for 45 minutes to avoid uneven dyeing.



After dyeing, to remove unfixed dye the fabric was subjected to the wash-off process by pressing it. The process of wash-off was carried out in six different steps. Each step was completed in ten minutes. First of all, the dyed fabric was rinsed under tap water. For the remaining five steps five beakers were taken with 50 ml of water in each. For the second step of wash-off, called neutralization, two to three drops of acetic acid were added to the beaker and the fabric was continuously stirred for ten minutes.

In the third step, the temperature of the beaker was set to 50°C and the fabric was added to it and stirred for ten minutes. In the next step, the water in the beaker was maintained at 80°C and two to three drops of soaping agent were added. Fabric was then added and stirred continuously. In the fifth step, the temperature of the water in the beaker was again set to 50°C and fabric was again stirred continuously for ten minutes. In the last and sixth step, fabric was added in the beaker having water at room temperature and stirred again. Fabric dyed in fresh water was termed as standard. So in the overall process, an average of 5 samples were taken for each dye wastewater wash-off, and treatment was applied for 2 mixed samples.

# CHAPTER 4

# RESULTS AND DISCUSSIONS

## 4.1 Results

#### 4.1.1 Effect of Electrolysis Time on Dye Removal

#### The effect of electrolysis time was observed on the EC performance. A bench scale laboratory procedure was conducted to measure the percentage of dye removal. The tables 4.1.1 and 4.1.2 illustrate the removal of reactive dyes as the function of operational parameter. It is clearly observed that time has considerable effect on the removal of dyes.

**Table 4.1.1. Percentage of color reduction of C.I. Reactive Red 221**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **% Color Reduction on Electro Coagulation Time(min)** | | | | | | |
| **Reactive Red 221 (Dye Shade**  **(%)** | **pH** | **Time (minutes)** | | | | |
| **5** | **10** | **15** | **20** | **25** |
| **5** | 4 | 10 | 25 | 40 | 65 | 80 |
| 7 | 35 | 52 | 85 | 91 | --- |
| 10 | 39 | 55 | 84 | 93 | --- |
| **3** | 4 | 15 | 33 | 46 | 70 | 82 |
| 7 | 38 | 66 | 81 | 92 | --- |
| 10 | 41 | 68 | 87 | 96 | --- |
| **1** | 4 | 19 | 32 | 55 | 67 | 83 |
| 7 | 40 | 64 | 85 | 94 | --- |
| 10 | 4 | 68 | 86 | 98 | --- |

#### Table 4.1.1. shows the treatment of wastewater at pH of 4, 7 and 10 for three different shades (1%, 3%, and 5%). Maximum color removal observed within 15-20 minutes for pH 7and 10 i.e. 96%.

**Table 4.1.2: Percentage of color reduction of C.I. Reactive Yellow 145**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Color reduction (%) on Electro Coagulation time (min)** | | | | | | |
| **Dye Shade**  **(%)** | **pH** | **Time (minutes)** | | | | |
| 5 | 10 | 15 | 20 | 25 |
| **5** | 4 | 19 | 38 | 63 | 76 | 82 |
| 7 | 38 | 55 | 80 | 93 | - |
| 10 | 40 | 59 | 81 | 94 | - |
| **3** | 4 | 21 | 40 | 65 | 76 | 83 |
| 7 | 40 | 58 | 81 | 94 | - |
| 10 | 43 | 62 | 83 | 95 | - |
| **1** | 4 | 23 | 45 | 67 | 78 | 85 |
| 7 | 42 | 60 | 82 | 94 | - |
| 10 | 45 | 65 | 83 | 96 | - |

#### Table 4.1.2 shows that C.I. Reactive Yellow 145 wastewater treated at pH of 4, 7 and 10. Maximum color removal observed within 15-20 minutes for pH 7 and 10 i.e. 96%.

# 

#### 4.2 Effect of pH

#### The tables 4.2.1 and 4.2.2 shows the results of removal of C.I. Reactive Dyes were significantly affected by change in pH. To study its effect, pH of standard wastewater was set to desire values of 4, 7 and 10 by adding acetic acid (CH3COOH) and sodium hydroxide (NaOH).

**Table 4.2.1 pH of Untreated and Treated wash-off of C.I. Reactive Red 221**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Shades (%)** | **5** | | **3** | | **1** | |
| **Sample** | **Untreated pH value** | **Treated pH value** | **Untreated pH value** | **Treated pH value** | **Untreated pH value** | **Treated pH value** |
| **A** | 4 | 6.88 | 4 | 6.56 | 4 | 6.04 |
| **B** | 7 | 8.99 | 7 | 9.01 | 7 | 8.23 |
| **C** | 10 | 10.43 | 10 | 10.65 | 10 | 10.88 |

**Table 4.2.2 Untreated and Treated Wash-off of C.I. Reactive Yellow 145**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sample** | **Untreated pH value** | **Treated pH value** | **Untreated pH value** | **Treated pH value** | **Untreated pH value** | **Treated pH value** |
| **A** | 4 | 6.85 | 4 | 7.08 | 4 | 7.45 |
| **B** | 7 | 7.86 | 7 | 8.41 | 7 | 8.67 |
| **C** | 10 | 10.74 | 10 | 10.85 | 10 | 10.97 |

#### Table 4.2.2 shows that when pH reaches to maximum basic level, the excellent removal efficiency achieved. The experimental results evaluated that when pH varies from 7 to 10 of dyeing wastewater, the removal efficiency increased.

# 

#### 4.3 Color Measurement

#### The Sample of each reactive dye shades were subjected to test the color differences. The Reflectance Spectrophotometer was used to observe the value in D65 10 deg., msTL84-10 and A 10 Deg. The tables given below show the difference between colors.

**Table 4.3.1 Values of color difference of C.I. Reactive Red 221 (5%)**

| **Sample** | **III/Obs** | **∆L\*** | **∆A\*** | **∆B\*** | **∆C\*** | **∆H\*** | **∆E\*** | **∆ECMC** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **A** | D65 10 Deg | -2.66 | -5.49 | 10.83 | -3.53 | 11.62 | 12.43 | 6.57 |
| msTL84-10 | -2.65 | -4.10 | 12.11 | -0.58 | 12.77 | 13.06 |
| A 10 Deg | -2.91 | -3.64 | 9.23 | 0.58 | 9.91 | 10.34 |
| **B** | D65 10 Deg | -1.56 | -0.01 | 1.41 | 0.12 | 1.41 | 2.11 | 1.09 |
| msTL84-10 | -1.54 | -0.24 | 1.47 | 0.02 | 1.49 | 2.14 |
| A 10 Deg | -1.46 | 0.14 | 1.55 | 0.68 | 1.40 | 2.41 |
| **C** | D65 10 Deg | -5.29 | -3.76 | 1.32 | -3.63 | 1.64 | 6.63 | 3.06 |
| msTL84-10 | -5.73 | -4.26 | 0.67 | -4.07 | 1.40 | 7.17 |
| A 10 Deg | -5.63 | -2.96 | 0.58 | -2.57 | 1.59 | 6.39 |

**Table 4.3.2 Values of color difference of C.I. Reactive Red 221 (3%)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sample** | **III/Obs** | **∆L\*** | **∆A\*** | **∆B\*** | **∆C\*** | **∆H\*** | **∆E\*** | **∆ECMC** |
| **A** | D65 10 Deg | -3.84 | -5.00 | 10.38 | -2.99 | 11.13 | 12.14 | 6.45 |
| msTL84-10 | -3.83 | -4.13 | 11.51 | -0.58 | 12.21 | 12.81 |
| A 10 Deg | -4.03 | -3.08 | 8.95 | 1.08 | 9.40 | 10.29 |
| **B** | D65 10 Deg | -0.70 | 0.75 | 1.66 | 0.92 | 1.57 | 1.95 | 0.98 |
| msTL84-10 | -0.57 | 0.52 | 1.80 | 0.86 | 1.66 | 1.95 |
| A 10 Deg | -0.50 | 0.78 | 2.01 | 1.47 | 1.58 | 2.21 |
| **C** | D65 10 Deg | -2.26 | 1.14 | 3.10 | 1.48 | 2.95 | 4.00 | 1.03 |
| msTL84-10 | -2.07 | 0.54 | 3.33 | 1.23 | 3.14 | 3.96 |
| A 10 Deg | -1.91 | 1.36 | 3.69 | 2.66 | 2.89 | 4.37 |

**Table 4.3.3 Values of color difference of C.I. Reactive Red 221 (1%)**

| **Sample** | **III/Obs** | **∆L\*** | **∆A\*** | **∆B\*** | **∆C\*** | **∆H\*** | **∆E\*** | **∆ECMC** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **A** | D65 10 Deg | -4.79 | -9.06 | 19.84 | -4.49 | 21.35 | 22.33 | 11.80 |
| msTL84-10 | -4.92 | -7.51 | 21.49 | -0.19 | 22.76 | 23.29 |
| A 10 Deg | -5.06 | -5.62 | 17.41 | 2.79 | 18.08 | 18.98 |
| **B** | D65 10 Deg | 1.73 | 0.61 | -166.40 | -0.63 | -1.39 | 2.31 | 1.12 |
| msTL84-10 | 1.56 | -0.36 | -1.70 | -0.53 | -1.66 | 2.34 |
| A 10 Deg | 1.55 | -0.85 | -1.66 | -1.30 | -1.34 | 2.42 |
| **C** | D65 10 Deg | 1.66 | -2.17 | -1.65 | -2.19 | -1.61 | 3.19 | 1.41 |
| msTL84-10 | 1.30 | -1.84 | -2.21 | -2.05 | -2.02 | 3.15 |
| A 10 Deg | 1.26 | -2.10 | -2.37 | -2.70 | -1.66 | 3.41 |

**Table 4.3.4 Values of color difference of C.I. Reactive Yellow 145 (5%)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sample** | **III/Obs** | **∆L\*** | **∆A\*** | **∆B\*** | **∆C\*** | **∆H\*** | **∆E\*** | **∆ECMC** |
| **A** | D65 10 Deg | -4.16 | -1.48 | -5.68 | -5.75 | -1.14 | 7.20 | 2.60 |
| msTL84-10 | -4.37 | -1.56 | -6.00 | -6.16 | -0.70 | 7.59 |
| A 10 Deg | -4.48 | -1.08 | -6.07 | -6.01 | -1.40 | 7.62 |
| **B** | D65 10 Deg | -1.07 | -0.55 | -1.47 | -1.57 | -0.13 | 1.90 | 0.60 |
| msTL84-10 | -1.15 | -0.52 | -1.62 | -1.70 | -0.09 | 2.05 |
| A 10 Deg | -1.17 | -0.56 | -1.59 | -1.69 | -0.10 | 2.06 |
| **C** | D65 10 Deg | 0.57 | 0.52 | 0.74 | 0.89 | -0.16 | 1.07 | 0.38 |
| msTL84-10 | 0.64 | 0.40 | 0.88 | 0.96 | -0.06 | 1.16 |
| A 10 Deg | 0.66 | 0.50 | 0.88 | 1.01 | -0.12 | 1.21 |

**Table 4.3.5:** Values of color difference of C.I. Reactive Yellow 145 (3%)

| **Sample** | **III/Obs** | **∆L\*** | **∆A\*** | **∆B\*** | **∆C\*** | **∆H\*** | **∆E\*** | **∆ECMC** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **A** | D65 10 Deg | -0.43 | 0.70 | 0.28 | 0.54 | -0.52 | 0.87 | 0.44 |
| msTL84-10 | -0.40 | 0.56 | 0.33 | 0.50 | -0.41 | 0.76 |
| A 10 Deg | -0.35 | 0.54 | 0.53 | 0.69 | -0.30 | 0.83 |
| **B** | D65 10 Deg | -1.21 | 0.49 | -0.95 | -0.67 | -0.84 | 1.61 | 0.79 |
| msTL84-10 | -1.22 | 0.47 | -0.94 | -0.73 | -0.76 | 1.61 |
| A 10 Deg | -1.19 | 0.39 | -0.81 | -0.60 | -0.67 | 1.49 |
| **C** | D65 10 Deg | -0.77 | 0.33 | -0.48 | -0.30 | -0.50 | 0.96 | 0.48 |
| msTL84-10 | -0.76 | 0.19 | -0.50 | -0.40 | -0.35 | 0.93 |
| A 10 Deg | -0.75 | 0.23 | -0.33 | -0.22 | -0.34 | 0.85 |

**Table 4.3.6:** Values of color difference of C.I. Reactive Yellow 145 (1%)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sample** | **III/Obs** | **∆L\*** | **∆A\*** | **∆B\*** | **∆C\*** | **∆H\*** | **∆E\*** | **∆ECMC** |
| A | D65 10 Deg | -9.59 | 0.34 | -8.97 | -8.33 | -3.35 | 13.13 | 5.11 |
| msTL84-10 | -9.89 | 1.10 | -9.39 | -8.78 | -3.49 | 13.68 |
| A 10 Deg | -9.87 | 1.05 | -9.30 | -8.41 | -4.11 | 13.60 |
| B | D65 10 Deg | -0.22 | 0.41 | 0.21 | 0.32 | -0.32 | 0.50 | 026 |
| msTL84-10 | -0.21 | 0.40 | 0.19 | 0.28 | -0.34 | 0.49 |
| A 10 Deg | -0.17 | 0.34 | 0.29 | 0.38 | -0.23 | 0.48 |
| C | D65 10 Deg | -2.17 | 1.62 | -0.10 | 0.43 | -1.57 | 2.71 | 1.36 |
| msTL84-10 | -2.15 | 1.41 | -0.20 | 0.15 | -1.41 | 2.58 |
| A 10 Deg | -2.03 | 1.18 | 0.38 | 0.73 | -1.00 | 2.37 |

#### 4.4 C.I. Reactive Red 221

#### When the electrolysis time for 5% dye shade increased from 10 to 20 minutes, the removal efficiency also increased from 55 to 93% and remained constant after this. The removal efficiency increased when dye concentration decreased. The removal efficiency of 3% was 96% in 20 minutes i.e. more than the 5% dye shade. And the excellent color removal was observed in 1% dye shade i.e. 98% within 20 minutes at pH 10.

**Graph 4.4.1(a) Color reduction percentage of C.I. Reactive Red 221 for 5% shade**

**Graph 4.4.1(b) Color reduction percentage of C.I. Reactive Red 221 for 3% shade**

**Graph 4.4.1 (c) Color reduction percentage of C.I. Reactive Red 221 for 1% shade**

# 

#### 4.5 C.I. Reactive Yellow 145

#### The result of C.I. Reactive Yellow 145 with dye shades (1%, 3%, 5%) showed that as dye concentration decreased the removal efficiency increased. The pH 4 consumes more time to remove dyes from dyeing wastewater than pH 7 and 10. The maximum removal efficiency of pH 4 was 84 %, after 25 minutes further increased in electrolysis time, the color reduction remain unchanged.

**Graph 4.5.1 (a) Color reduction percentage of C.I. Reactive Yellow 145 for 5% shade**

**Graph 4.5.1 (b) Color reduction percentage of C.I. Reactive Yellow 145 for 3% shade**

**Graph 4.5.1 (c) Color reduction percentage of C.I. Reactive Yellow 145 for 1% shade**

#### 

#### 4.6 Effect of pH

#### The effect of pH 4 on efficiency of EC indicates least color removal that was below 84%. However, when pH reaches to maximum basic level, excellent removal efficiency achieved. The experimental results evaluated that when pH was changed from 7 to 10 of dyeing wastewater, the removal efficiency increased.

**Graph 4.6 (a) pH of Treated wash-off of C.I. Reactive Red 221**

**Graph 4.6 (b) pH of treated wash-off of C.I. Reactive Yellow 145**

#### 4.7 Color Measurement

#### The Sample of each C.I. Reactive Dye shades was tested to find the color differences. Color strength measurement described how much a Sample is lighter or darker as compared to standard value. The K/S value of Sample C was greater than Sample A, B and standard. The standard has k/s value “13.5” which showed that Sample C was darker in shade and Sample A and B indicated lower change in color.

#### The graph showed that K/S value of Samples A, B and C was greater than standards. The K/S value of Sample C is 19.3 that was greater than standard value 14.4 and showed darker shade as compared to other Samples.

#### The Sample A has greater value of K/S than standard that is 10.3 and showed darker shade. Sample B and C showed different behavior than Sample A. Sample B and C have lesser values than standard that means they have lighter shade.

#### The graph showed darker shade of Sample A because it has greater value of K/S that was 24.2 than standard. Sample B and C have negligible change in shades as compared to standard.

#### The K/S value of standard was similar to three Samples which showed no difference in shades.

All Three samples have greater value of K/S than standard value of K/S that is 8.7. They have darker shades when compared to standard.

# ****CHAPTER 5****

# ****CONCLUSION AND RECOMMENDATIONS:****

## 5.1 Conclusion:

This study examined the possibility of the reuse of dye baths after decolorization and degradation of wastewater obtained from dyeing processes of reactive dyes by using electrocoagulation. The conclusion drawn from this study suggested that

* Electrocoagulation is the most promising technique in reuse of textile wastewater by dye removal.
* Electrocoagulation is an effective process to treat the textile wastewater. The purpose of conducting this research was to study the color removal efficiency by using electrocoagulation treatment method and make it feasible for reuse.To initiate a method to overcome the water paucity issue.
* Dye wastewater was treated at three different pH (4, 7, and 10). EC technique developed to remove the organic and inorganic matter from wastewaters for the protection of environment and water resources.
* Maximum Removal efficiency of 96% was observed for C.I. Reactive Dyes. These removal efficiencies were obtained at pH 10 within time interval of 15-20 minutes.
* Under control conditions, electrocoagulation for decolonization of textile wastewater is a sustainable alternative for reuse in dying process.
* The procedure prohibits the discharge of textile waste water with a high content of salts into the environment, ultimately saving water.

#### There was less sludge formation than other treatment methods hence EC is environmental friendly, reliable and highly efficient.

## 

## 5.2 Recommendations

Wastewater discharged from Textile Industries is being treated through various effective methods but still it is a major concern for environment. Industries should have minimal water discharge to less water consumption or reuse. Zero discharge method is the most appropriate way to overcome wastewater challenges. By using this approach, wastewater would be minimized at its source. Zero water discharge is highly recommended as it is a more convenient and environmental friendly way in water management and quality control.

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