

# **Adsorption of Reactive Dye Corafix Yellow GD-3R from Aqueous Solution using Corn Cob**

**BY**

**R.SANDHIYA**

**(20pbx007)**

**A Thesis submitted to the**

**Avinashilingam Institute for Home Science and Higher Education for women**

**Coimbatore -641043**

**In partial fulfillment of the requirements for the**

**Degree of Master of Science**

**In**

**BIO TEXTILES**

**May 2022**

**CERTIFICATE**

# Adsorption of Reactive Dye Corafix Yellow GD-3R from Aqueous Solution using Corn Cob

BY

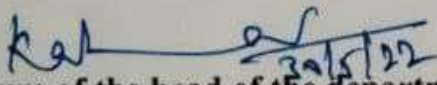
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Certified as Bonafide Research work

  
Signature of the head of the department

  
Signature of the supervisor

ACKNOWLEDGEMENT

**CERTIFICATE FROM THE SUPERVISOR**

I certify that dissertation entitled "Adsorption of Reactive Dye Corafix Yellow GD-3R from Aqueous Solution using Corn Cob" submitted for the degree of Master of science (M.Sc.) Biotextiles by Sandhiya R is the record of project work carried out by her during the academic year 2021 to 2022 under my guidance and supervision and this work has not formed the basis for the award of any Degree, Diploma, Associate ship, Fellowship, Titles in this University or any other similar institution of higher learning.

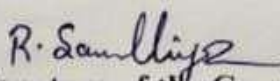
  
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## **DECLARATION**

## DECLARATION

I declare that the dissertation entitled "**Adsorption of Reactive Dye Corafix Yellow GD-3R from Aqueous Solution using Corn Cob**" submitted by me for the degree of Master of science (M.Sc.) is the record of work carried out by me during the period from 2021 to 2022 under the guidance of Dr. (Tmt.) K.KALAIARASI, M.Sc., M.Phil., Ph.D. (Avinashilingam), Associate Professor, Department of Textiles and Clothing, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore-642 043 and has not formed the basis for the award of any Degree, Diploma, Associate ship, Fellowship, Titles in this University or any other similar institution of higher learning

  
Signature of the Candidate

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## ACKNOWLEDGEMENT

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## **INTRODUCTION**

## 1. Introduction

Contamination of the environment by poisonous organic compounds such as manmade and natural dyes, pigments, pesticides and other chemicals has been a major concern for living organisms including human, aquatic organisms and plants. (Dahiru et al., 2018). High levels of dissolved coloured pigments are found in wastewaters discharged during dyeing and printing processes. The ecosystem is harmed when coloured wastes such as dyes and pigments are dumped into receiving streams (Hossain et al., 2018).

Synthetic dyes are widely utilized in the textile industry and the majority of them are water soluble. In most textile dyeing operations, up to 15% of the colours used do not connect to the fibres and end up in the wastewater. Due to the colour concentration and hazardous components, the resulting effluent creates major water pollution. The introduction of heavy metals into water bodies, as well as an increase in biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH and suspended particles, are all problems connected with coloured textile effluent. Furthermore, the presence of synthetic dyes in wastewater causes the water to smell bad and look bad, as well as reducing the quantity of sunlight that reaches the water, impacting photosynthesis and entire aquatic ecosystems (Afena et al., 2021) are associated with heavy disease burden to the human (Kaur and Sharma, 2015)

To prevent and minimize water pollution, a range of treatment systems are available, each with varying degrees of efficacy. Many treatment processes have been used to remove dye from wastewater, including the Fenton process, photo/ferrioxalate system, photo-catalytic and electrochemical combined treatments, photo-catalytic degradation using UV/TiO<sub>2</sub>, sono-chemical degradation, Fenton-biological treatment scheme, biodegradation, photo-Fenton processes, integrated chemical biological degradation, electrochemical degradation, adsorption process and chemical coagulation/flocculation methods ((Harshananda et al., 2020).

However, most of these systems have drawbacks such as high operating and maintenance costs, toxic sludge production, and difficult treatment procedures. Because of its convenience, ease of operation simplicity of design and their efficacy in removing pollutants the adsorption process is regarded a preferable choice in water and wastewater treatment (Helly and Dhvani, 2019), (Devanath et al., 2020).

The adsorption technique is an appealing option for dye-contaminated water treatment, especially if the sorbent is affordable (Harshananda et al., 2020). Activated carbon as adsorbent is expensive on the other hand using agricultural waste as adsorbents, on the other hand, is a simple effective strategy and may be considered a suitable item that can influence environmental management. As a result, converting agricultural waste into adsorbent, soil enhancement material, and solid fuel, among other things, could be an effective way to alleviate global environmental stress (sonu et al., 2020). They're also readily available, low-cost adsorbents with outstanding adsorption properties (Devananth et al., 2020). Natural agricultural materials with the ability to absorb both acidic and basic dyes could be a more cost-effective alternative adsorbent (Harshananda et al., 2020).

Several agricultural waste products are being investigated for their ability to remove various colours from aqueous solutions under various operating circumstances. Agricultural waste consists of coir pith, orange peel, banana peel, rice straw, rice husk, date pit, oil palm trunk fiber, durian peel, guava leaf powder, almond shell, pomelo peel, broad bean, peanut hull (Bharathi and Ramesh, 2013) are continuously being explored for dye removal from wastewaters due to their abundance, high carbonaceous contents and high affinity towards organic molecules (Harshananda et al., 2020). The use of this waste further eliminates its accumulation and deterioration in the environment, making it safer and cleaner for the general public (Abdulsalam et al., 2020).

Hence the present study “**Adsorption of Reactive Dye Corafix Yellow GD-3R from Aqueous Solution using Corn Cob**” investigates the potential use of low cost adsorbents for the removal of Corafix Yellow GD-3R from aqueous solution with the following objectives

- To optimize various parameters such as adsorbent dosage, initial dye concentration, time, temperature and pH for efficient removal of dye from aqueous solution
- To screen various agro-wastes as adsorbent for decolourization of selected reactive dye
- To assess phytotoxicity of decolourized dye solution and reuse the decolourized dye solution for dyeing
- To compare the properties of the fabrics dyed with fresh water and decolourized water

## **REVIEW OF LITERATURE**

## **2. REVIEW OF LITERATURE**

The persistence of most synthetic dyes in textile industry effluents, their potential hazardous effects on human health and the environment, and public demands have led to strict environmental regulations and low cost adsorbents obtained from agricultural waste products were found to be having outstanding removal capabilities. The review pertaining to the present study is discussed under the following headings

### **2.1 Textile Dyeing**

### **2.2 Synthetic dyes**

#### 2.2.1 Reactive dyes

#### 2.2.2 Azo dyes

### **2.3 Effect of textile dyes on environment**

### **2.4 Decolourisation**

#### 2.4.1 Decolourisation methods

#### 2.4.2 Adsorption technique

### **2.5 Agro wastes in textiles**

### **2.6 Removal of textile dye using agro waste adsorbent**

### **2.7 Corn cob**

## 2.1 Textile dyeing

Dyeing in textiles is a process in which color is transferred to a finished textile or textile material to add permanent and long lasting color. It can be done by hand or by machine. Dyes can come as powders, crystals, pastes, or liquid dispersions, and they dissolve completely in an aqueous solution like water. When these colorants have a natural affinity and permanence on textiles, they are referred to as dyes. Dyes actually migrate or diffuse into the chemical molecular structure of textile fibers in order to develop the final color of the textile product (Priya, 2022)

When the textile and the dye come into contact, the textile is completely saturated by the dye and colored. The textile dyeing and finishing industry has caused major pollution problems as it is one of the most chemical-intensive industries on the planet. Currently, over 3600 individual textile dyes are produced by this industry. The industry uses over 8000 chemicals in a variety of textile manufacturing processes, including dyeing and printing (Kant,2011). Textiles are dyed using a variety of dyes, techniques and equipment. The dyes used in the textile industry are predominantly synthetic and usually come from coal tar and petroleum-based intermediates. Dyes are usually sold at an active ingredient concentration of 20-80 percent (Priya, 2022).

In short, the dyeing process is a very complex chemical reaction. It involves the use of dyes and other auxiliary chemicals known as excipients and is processed under optimal conditions. Different classes of dyes applied to different fiber types require careful selection of such dyeing aids and conditions (Imran, 2021). Natural dyes, known for a long time, are mainly obtained from plants. Synthetic dyes are artificially synthesized from compounds. Synthetic dyes are divided into three groups based on the type of fiber produced. These are cellulose fiber dyes, protein fiber dyes, synthetic fiber dyes (Slama *et al.*, 2021), and some dyes are highly toxic and mutagenic, reducing light transmission and photosynthetic activity (Chequer, 2013)

Specific hues and fastness dyes due to the different interactions of the dye's molecular orbitals with the substrate and the ease with which the dye can release its absorbed energy to the surroundings without self-decomposition. It can vary depending on the substrate. (Chatwal, 2020).

## 2.2 Synthetic dyes

Synthetic dyes are manufactured from organic molecules, these dyes are made from synthetic resources such as chemicals, petroleum byproducts, and earth minerals. Synthetic dyes have been widely used in supramolecular chemistry not only to probe fundamental chemical interactions but also as components of functional materials (Ziarani *et al.*, 2018) however, the commercial role of synthetic dyes day by day has been increasing thoroughly. At present, they possess diversified angles of coloration such as textiles and clothing`s, leather, fur, photography, refined petroleum products, food, paper, printing, plastic, fashion and design, body art, paint, etc. It is assumed that about 10–15% of synthetic dyes are suspended during different processes of the textile industry as effluent (Yusuf, 2019)

The textile industry uses a large variety of synthetic dyes. However, Azo dyes are the most employed. Further, textile industry dyes are classification according to their industrial application as acid, basic, reactive, vat, disperse and direct dyes. In general, synthetic dyes are not biodegradable due to their chemical properties and structure, generating an adverse effect on the environment most synthetic dyes are recalcitrant, carcinogenic and toxic for ecosystems. Which means that dyes can persist for a long time (~50 years or more) in the environment (Leal, 2021) Synthetic dyes come from oil, which is a nonrenewable resources. Synthetic dyes were still being produced from coal tar until about 30years ago. Extracting and burning coal is a major contributor to greenhouse gas emissions, and therefore climate change (Okrainsky, 2021).

Synthetic dyes are sometimes referred to as `coal tar dyes`. Though it is harmful for human being and environment but synthetic dyes are playing important roles in our modern life with applications in both industry and scientific laboratories. Synthetic dyes are widely used in the field of textile, paint, and printing. Acid dye, basic dye, reactive dye, direct dye, sulfur dye, disperse dye are example of synthetic dyes (Alvi, 2020).

Although synthetic dyes constitute only a small proportion (less than or equal to 1 ppm) of the industrial effluent, they are quite stable and are resistant to light, various chemicals, and biological activities owing to their complex structure, remaining as such for a long period. Therefore, their accumulation causes an increase in biochemical oxygen demand (BOD), affecting pH and chemical oxygen demand (COD) (Forgacs *et al.*, 2004).

### **2.2.1 REACTIVE DYES**

The reactive dyes constitute the most commonly used class of dyes for dyeing cellulosic textiles, because of their good all round properties, such as water solubility, ease of application, variety of application methods, availability of different shades, brightness of color shades, good to excellent wash and light fastness and moderate price. Reactive dyes may have poor fastness to chlorine bleach. Here the dye contains a reactive group and this reactive group makes covalent bond with the fibre polymer and act as an integral part of fibre (Kiron, 2021)

There are many types of reactive dyes with different reactive groups, with different reactive systems, that react with substrate to form covalent bonds. The chromophore of their molecules are very similar either azo, anthroquinone, phthalocyanine chromophore or others (Thiagarajan, 2014) these chemical classes are used for dyeing and printing of cotton, wool etc. the molecule structure of reactive dyes have much simpler than direct dyes and the dyeing are brighter (Mulla and Ranveer, 2015).

This process in which a dye interacts with water is known as reactive dye hydrolysis. The disadvantages of reactive dyes are Color is not easily removed by effluent treatment processes and in many cases, the dyes are not readily biodegradable and need for high concentration of salt (Ahmed, 2014). These dyes have very stable electron arrangement and the degrading effect ultraviolet ray. Reactive dyes give brighter shades and have moderate rubbing fastness and are comparatively cheap. They have good perspiration fastness with rating 45 and Fixation occurs in alkaline condition. (Hossain, 2021).

The disadvantage of reactive dyes is that the colors cannot be easily removed in the wastewater treatment process, and in many cases the dyes are not easily biodegradable and require high salt concentrations (Ahmed, 2014)

### **2.2.2 AZO DYES**

Azo dyes are the most important group of synthetic dyes. They are generally considered to be xenobiotic compounds that are very difficult to handle for the biodegradation process. In particular, aromatic azo compounds are used as acid-base indicators and are also used in commercial dyes for biological strains, clothing, plastics, cosmetics and food and beverages. All non-dye-related parameters such as temperature, pH, type and source of reduction equivalent, bacterial consortium, and cell permeability can affect the biodegradation of azo dyes and fiber effluents (AlRubaie, 2012). Azo dyes represent the largest production volume of dye chemistry today, and their relative importance may even increase in the future. They play a crucial role in the governance of the dye and printing market.

These dyes are synthesized from a simple method of diazotization and coupling. Different routes and modifications are made to obtain the desired color properties, yield and particle size of the dye for improved dispersibility (Benkhaya et al., 2020)

Azo dyes are the main synthetic dyes and are widely used in textiles, printing, papermaking, etc., accounting for more than 60% of all dyes. About 70% of all dyes used in the industry are azo dyes (Benkhaya *et al.*, 2020). Azo class dyes have been extensively studied to find out their uses and adverse effects. 60% to 70% of azo dyes are toxic, carcinogenic and resistant to conventional physicochemical treatments. Toxicity of azo dyes follows chemical reduction followed by the formation of aromatic amines, followed by colored water or contaminated sewage sludge contacting aquatic animals, transmitting toxic compounds to humans through the food chain and causing health problems. Causes (Leal *et al.*, 2021).

Approximately 1520% of the total dye is released into the environment during the process, causing terrible environmental effects (Ouasif *et al.*, 2013). As the molecular weight of the azo dye increases, the distribution of the dye in the water increases, resulting in a decrease in the decomposition rate of azo dyes. The color of the azo dye is determined by the chromophores and auxochromes associated with the azo bond. Azo dyes are generally characterized by chemical groups capable of forming covalent bonds with the fiber substrate (Benkhaya, 2020). While azo dyes meet human needs, they also bring ecological and health changes to water resources, soil and air.

### **2.3 Effect of textile dyes on environment**

Textile dyes are highly toxic and can be carcinogenic with a variety of industrial pollutants (Sharma *et al.*, 2018) and are therefore associated with environmental degradation and various diseases in animals and humans (Khan & Malik). , 2018). However, the main environmental harm caused by the textile industry results from the discharge of untreated wastewater into water bodies and Bhatia, 2017), which is typically 80% of the total emissions from this industry. Occupy (Wang, 2016). Dyes are soluble organic compounds, especially classified as reactive, direct, basic and acidic. They show high water solubility and make it difficult to remove those using conventional methods (Hassan & Carr, 2018).

Colors associated with fiber dyes not only aesthetically damage the aquatic environment (Setiadi et al., 2006), but also prevent the transmission of light through water, resulting in slower photosynthetic rates (Imran *et al.*, 2015) and levels of dissolved oxygen affecting all aquatic fauna (Hassan & Carr, 2018). Particular mention should be made of azo-type fiber dyes that do not bind to the fabric during the dyeing process. Approximately 15-50% is released into wastewater commonly used for irrigation purposes in agriculture in developing countries. The use of these azo compounds is highly

negative for microbial communities in soil and the germination and growth of plants (Rehman *et al.*, 2018).

Therefore, it is essential to apply therapeutic strategies aimed at ensuring environmental sustainability for future generations (Jordao *et al.*, 2018). Although physicochemical means have been successful, they have been observed to result in inconveniences caused by sludge disposal and the high cost of electricity, utilities, or operations (Imran *et al.*, 2015).

Biodegradation has been proposed as the most economical resource for treating textile wastewater. Process water is saturated with chemical additives and discharged as wastewater. This pollutes the environment as follows: The heat of sewage. Its high pH; because it is saturated with dyes, modifiers, bleaches, detergents, optical brighteners, leveling agents, and many other potentially harmful compounds used in the wet process of fibers (Starovoitova and Odido., 2014)

In addition, dyes are highly toxic to the growth of microorganisms through absorption, deposition and ion exchange using dead bacteria, yeasts and fungi (Doble & Kumar, 2005). In this sense, the purpose of this study is to investigate the main effects of textile dyes on health and the environment.

## **2.4 Decolourisation**

Discoloration is the disappearance of a complex dye molecule without actually breaking it down, which occurs when the chromophore bond is broken, but the main fragment of the original molecule remains.(Hao *et al.*, 2000) Discoloration of wastewater is now a major problem for sewage treatment facilities in various industries. Microorganisms and agricultural waste are currently being investigated as potential contributors to discoloration and colorant degradation due to environmentally friendly processes and inexpensive treatment options. Studies have reported the ability of microorganisms to decolorize various dyes. (Christina *et al.*, 2016).

Color removal in particular has recently become a very interesting field of science, as evidenced by numerous relevant research reports. Several bleaching techniques have been reported in the last 20 years, some of which have been accepted by some industries (Anjaneyulu, 2005).

### **2.4.1 Decolourisation methods**

Various chemical and physical methods are available for decolorization, including coagulation / aggregation, precipitation, adsorption, oxidation and advanced oxidation processes, electrolysis, and membrane extraction (Zhang *et al.*, 2004). However, these methods have limited scope due to their inefficiency, high budget, and toxic intermediates (Verma *et al.*, 2003; Zhang *et al.*, 2004). Due to the

complex nature of contaminants and residues from by-products, municipal wastewater systems are inadequate for efficient decolorization of wastewater (Champagne and Ramsay, 2010).

Therefore, biodegradation of dyes using microorganisms and agricultural waste as adsorbents is considered to be one of the environmentally friendly methods (O`neill *et al*, 2000). Non-catalytic reactions are usually inefficient and adsorption usually shows a slight discoloration. In these cases, the combination of activated carbon and hydrogen peroxide can significantly improve the process as the activated carbon catalyzes the decomposition of H<sub>2</sub>O<sub>2</sub> into hydroxyl radicals. This is very reactive. (Santos *et al.*, 2009). Aggregation / aggregation is used to separate suspended solids fractions from water and occurs in successive steps, allowing particle collisions and floc growth. If coagulation is incomplete, the agglomeration step fails and the agglomeration is a mild mixing step (Bellie, 2014).

Chemical precipitation is the most commonly used technique for removing metals from solutions such as: B. Treat wastewater containing toxic metals. Ionic metals are converted to insoluble forms by a chemical reaction between the soluble metal compound and the precipitation reagent. Adsorption has also been used to treat a variety of organic and inorganic contaminants from a variety of contaminated water bodies, as adsorption can reduce soluble and insoluble organic compounds (Amro *et al.*, 2021). The advanced oxidation process is a series of chemical processes designed to remove organic matter in wastewater by oxidation by reaction with hydroxyl radicals.

#### **2.4.2 Adsorption technique:**

Adsorption is a competitive technique for treating and purifying wastewater, groundwater, and industrial wastewater. This separation process can provide a satisfactory cost-effective trade-off for water pollution control. Overall, adsorption process engineering represents several factors that need to be analyzed, researched and optimized in order to develop economically and technically feasible water treatment strategies. (Bonilla *et al*, 2017). Adsorption has advantages over other methods due to its simple structure and may require a small investment in terms of both acquisition cost and space requirements. Adsorption processes are widely used to treat industrial wastewater from organic and inorganic pollutants (M. Rashed, 2013).

Adsorption is a mass transfer process that is a phenomenon of sorption of gases or solutes by solid or liquid surfaces. The adsorption on the solid surface is that the molecules or atoms on the solid surface have residual surface energy due to unbalanced forces. When some substances collide with the solid surface, they are attracted by these unbalanced forces and stay on the solid surface. According to

the different adsorption forces, the adsorption process can be divided into two categories: physical adsorption and chemical adsorption (Hu and Xu, 2020)

Adsorption can be classified in a variety of ways, but classification based on the strength of the bond is more common than physical and chemical adsorption. The behavior of adsorption of substances to the surface has been interpreted by thermodynamic, statistical and mechanical treatment (Bajpai and Rajpoot, 2000). Locally available materials such as natural materials, agricultural waste and industrial waste can be used as cheap adsorbents (Rashed, 2013).

Adsorption methods for this purpose have been widely used by several researchers and various materials have often been used as adsorbents. Adsorption has proven to be an effective purification method due to its key advantages such as stability, practicality, low cost, ease of operation and performance. Adsorption technology has a great advantage because it keeps the concentration of heavy metal ions extremely low and uses inexpensive adsorbents such as bioadsorbents, clay, activated carbon, zeolite, and metal oxides. Adsorption of metals to adsorbents, especially agricultural waste, is a fairly complex process as it is controlled by a variety of factors. This process includes complexing, chemisorption, surface and pore adsorption complexing, microprecipitation, and ion exchange (Muharrem and Ince, 2017).

Active carbon is by far the most commonly used adsorbent and is particularly suited to the removal of apolar compounds. Active carbon adsorption is a proven and much used technique because of the low energy and maintenance costs, the simplicity and the reliability. The effectiveness of the adsorption treatment is determined by the type of substance to be removed. Substances with a high molecular weight and low water solubility are better adsorbed with active carbon. In textile distribution, active carbon is used for the removal of difficult to degrade compounds, like colorants and Active carbon adsorption can also be used for the removal of PER from wastewater from the dry cleaning sector (Khulbe and Matsuura, 2018) The textile industry uses different classes of dyes and removal of colour from textile effluent is important to avoid contamination of water resources. Among the various treatment methods, adsorption occupies an important position in dye removal (Gedekar, 2015).

According to the vast amount of literature data, liquid phase adsorption is one of the most common color removal methods for dyes. Proper design of the adsorption process produces high quality treated wastewater. This process provides an attractive alternative for treating contaminated water, especially if the adsorbent is inexpensive and does not require additional pretreatment steps prior to application. In practice, adsorption techniques are versatile and easy to apply, but adsorption materials are expensive and some cannot be regenerated in large applications. Therefore, it is clear that there is a

need to use cheap, renewable and readily available adsorbents for such purposes. Otherwise, environmental protection will be compromised (Popuri *et al.*, 2016).

## 2.5 Agro wastes in textiles

Agricultural waste is a by-product of the production and processing of agricultural products and may contain materials that may benefit humans, but its economic value is collection, transportation, and for useful use. It is lower than the processing cost. Agricultural waste generally comes from a variety of sources, especially crops, livestock and aquaculture (Nwakaire and Ugwuishiwu, 2016). Agricultural waste has become an increasingly problematic issue in recent years as it can cause serious environmental problems. However, it can also be used for a variety of useful purposes as a raw material for energy production, chemical recovery, and adsorption of chemicals and dyes (Zhang *et al.*, 2012).

Discoloration of wastewater is now a major problem for treatment in various industries. Many industries use synthetic dyes to color products such as textiles, rubber, paper, plastics, leather, cosmetics and food. About 1015% of synthetic dyes and about 20% of these losses enter the environment through wastewater from wastewater treatment. Recently, many techniques have been used to decolorize dyes. Among them, adsorption technology has the greatest potential for removing dyes. After reviewing about 8085 research papers, it was concluded that low-cost adsorbents derived from agricultural waste have excellent removal capacity (Singh, 2012).

The use of bioadsorbents from agricultural waste such as corn stalks, bagasses and shavings has been used as a bioadsorbent carrier for fibrous waters. An increase in the particle size of the bio adsorbent during textile treatment resulted in decreased efficiency of the TSS and COD reduction. Bio adsorbents present an attractive option which is easy to adapt for textile wastewater treatment (Manyuchi *et al.*, 2018) Nowadays, there is numerous numbers of low cost, commercially available adsorbents coal, fly ash etc. agricultural waste like bagasse, pith, maize cob, coconut shell, rice husk and cellulose based wastes such as orange, lemon, banana and lychee are used for the dye removal as adsorbent (Arunchalam and Annadurai, 2011).

The agricultural solid wastes from cheap and readily available resources such as agave bagasse, almond shell, apricot shell, barley straw, cashew nut shell, citric acid, corncob, cotton and gingelly seed shell, depectinated pomelo peel, Egyptian mandarin peel, fruit juice residue, garden grass, garlic peel, grapefruit peel, hazelnut shell, lentil shell, mango peel waste, Mosambi (Citrus limetta) peel, muskmelon peel, pine sawdust, pongam seed shell, groundnut shell, olive stone, pomegranate peel, potato peel, rice shell, rice straw, sugarcane bagasse, walnut shell, banana peel, cane pith, coirpith, yellow passion fruit,

orange peel, rice husk, soy meal hull, sunflower stalk, white ash, white rice husk ash, wood derived biochar, pinewood, mixture almond shells, cassava peels, ash gourd peel, Cucumis sativa peel, lentil husk, neem bark, pomegranate peel, sunflower hull, wheat stem, carbon cloth, sky fruit husk and coconut shells have been investigated for the removal of numerous dyes from aqueous solutions. The basic components of the agricultural waste materials include hemicelluloses, lignin, lipids, proteins, simple sugars, water, hydrocarbons and starch, containing a variety of functional groups with a potential sorption capacity for various pollutants (Helly and Dhvani, 2019).

Peanut husks, an agricultural waste, have proven to be effective adsorbents for five anionic and cationic dyes. This process was found to be pH dependent, suggesting that adsorption is controlled by the interaction of charged dye molecules with the surface charge of the adsorbent (Etorki and Massoudi, 2011). Gum sawdust is used to remove the color of acidic sawdust and neutralize wastewater before it is released into the environment. (Hettige and Mowjood, 2015). The adsorbent can be made from the roots of water hyacinth, which is used to remove methylene blue from aqueous solutions. Fly ash is the main pollutant produced, but it has good potential as an adsorbent. Fly ash from thermal power plants can be used to remove methylene blue from aqueous solutions. (Abinaya *et al.*, 2016).

## **2.6 Removal of textile dye using agro waste adsorbent**

Activated carbon adsorption is a very useful technique. However, the main limitations are high manufacturing costs and energy consumption. Therefore, forest and agricultural waste may be an alternative option for removing dyes from wastewater due to its excellent performance and cost effectiveness (Gardazi, 2014). Agricultural waste is an inexpensive, high carbon material and is often used as a raw material for the production of activated and biochar (Okieimen *et al.*, 2007).

Agricultural waste has no economic value, but converting these wastes into activated carbon effectively contributes to the provision of new and inexpensive activated carbon that is efficient in removing colorants from contaminated water. Increase. A study of the literature emphasizes that agricultural waste is a promising raw material for the production of activated carbon with high mechanical strength, adsorption, and low ash content (Savova *et al.*, 2001). Bio adsorption is an attractive wastewater treatment process because it is not only low cost and easy to use, but also widely applicable to various types of wastewater. Agricultural waste is becoming an increasingly popular source of bio adsorbents and has been successfully used in wastewater treatment (Manyuchi *et al.*, 2018). Agricultural waste is a safe, environmentally friendly and inexpensive source of adsorbents for removing colorants (Wu *et al.*, 2021).

As a renewable resource, agricultural waste is a promising resource for environmental technology when used to treat water and wastewater (Bhatnagar *et al.*, 2015). Studies have shown that activated charcoal sucrose has the highest efficiency (98%) in removing RhB within 12 minutes (Xiao *et al.*, 2020). Cassava slag biochar showed 96% RhB removal. Equilibrium adsorption reached 480 minutes and pH 4 (Wu *et al.*, 2020; Singh *et al.* 2018) tested the adsorption of RhB from water using banana peel powder, with a maximum removal rate of Reactive blue. It was 81.07%. (Vigneshwaran *et al.*, 2021) removed reactive blue from contaminated water using a sulfur-bound tapioca skin biochar adsorbent.

## **2.7 Corn Cob**

Corn is one of the most widely planted crops in the world. During the processing of corn, a large volume of corncobs is generated as agricultural waste. The amount of corncobs generated worldwide is approximately 144 million tons per year, and most of it is discarded or burnt, causing serious environmental pollution and no benefit. Considering this, corncobs may be used as a value-added biosorbent for the removal of toxic organic and inorganic pollutants from wastewaters (Villamar *et al.*, 2018). Generally, in the Portuguese context, the corn plant and the corn cereal are used for cattle food and baking industry. In contrast, the corn cob does not have any significant specific application, being occasionally used for heating, and, therefore, it is mainly considered as an agriculture waste and there are already some recent research works highlighting the potential of the application of corn cob as an alternative sustainable raw building material (Pinto *et al.*, 2012).

Corn cob is one of the agricultural waste materials subjected to improper burning, which creates pollution. It can be used for the production of green technologies for further applications. Carbonisation or slow pyrolysis could be promising alternative to burning. It has many applications, such as soil ameliorant, waste water treatment, carbon sequestration, composting, supercapacitor, fuel cell and biocomposites material. It motivated to investigate the suitability of corn cob as a potential material for biochar production and its application. The advanced form of analysis, such as thermogravimetric, scanning electron microscopy, surface area, Fourier transform infrared spectroscopy, nuclear magnetic resonance spectroscopy and Raman spectroscopy, is elaborated for in-depth knowledge of characteristics. The hypothesis is that if the available corn cob is used for biochar production, it will reduce the carbon dioxide (CO<sub>2</sub>) emission. On a global level, conversion of available corn cob into biochar is expected to reduce CO<sub>2</sub> emission by 0.13 Gt per year (Wakudkar and Jain, 2022).

The yield of corn cobs may range from 1.42 to 1.53 dry and its moisture content may range from 20 to 55%. Corn cobs are collected during a limited harvest time, October–November. Therefore, there is a need to store corn cobs for year-around supply to large corn cob processing plants. Large volumes of corn cobs can be stored as piles outdoors or indoors. The higher heating value (HHV) of corn cobs ranges from 18.3 to 18.8 MJ/kg of dry matter (Ebeling and Jenkins, 2004) reported that the proximate analysis of corn cobs resulted in 80.10% volatiles, 1.36% ash, and 18.54% fixed carbon on a dry mass basis. They also reported that the ultimate analysis of corn cobs resulted in 46.58% carbon, 5.87% hydrogen, 45.46% oxygen, 0.47% nitrogen, 0.01% sulfur, 0.21% chlorine, and 1.40% ash on a dry mass basis thus, corn cobs are suitable for heating applications especially due to their low ash contents compared to other agricultural residues (Kaliyan and Morey, 2010)

## **METHODOLOGY**

# METHODOLOGY

The methodology pertaining to the study “Adsorption of reactive dye Corafix yellow GD-3R from aqueous solution using corn cob” is discussed under the following headings

## **3.1 Selection of synthetic dye**

## **3.2 Preparation of dye solution**

## **3.3 Selection of agro wastes**

## **3.4 Decolourisation process**

## **3.5 Optimization of various parameters for decolourization**

3.5.1 Effect of adsorbent dosage

3.5.2 Effect of pH

3.5.3 Effects of adsorbate concentration

3.5.4 Effects of time

## **3.6 Decolourization of selected dye solution under optimized conditions**

## **3.7 Characterization of decolourized water**

3.7.1 FTIR analysis

3.7.2 SEM analysis

3.7.3 UV analysis

## **3.8 Reuse of decolourized dye solution for dyeing**

3.8.1 Selection of fabric

3.8.2 Dyeing

## **3.9 Phytotoxicity studies**

## **3.10 Assessment of dyed fabrics**

3.10.1 Fabric Weight

3.10.2 Fabric Thickness

3.10.3 Fabric Strength

3.10.4 Fabric Stiffness

### **3.10.5 Absorbency test**

3.10.5.1 Fabric Wicking

3.10.5.2 Fabric Sinking

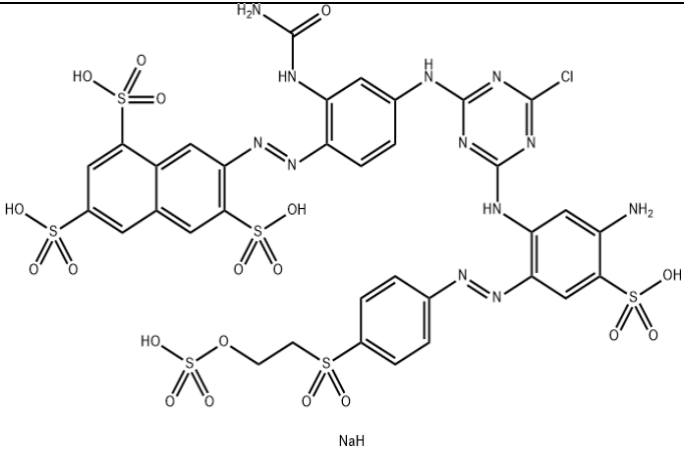
### **3.10.6 Colour Fastness Test**

3.10.6.1 Fastness to sunlight

3.10.6.2 Fastness to Washing

### 3.1 Selection of synthetic dyes

Corafix dyes are most widely used azo reactive dyes in the textile industries because of its flexible application and outstanding build-up and shades.

Name	Corafix Yellow GD-3R
Molecular formula	$C_{34}H_{30}ClN_{12}NaO_{19}S_6$
C.I. no	171599-84-1
Chemical structure	 <p>The chemical structure of Corafix Yellow GD-3R is a complex azo reactive dye. It features a central azo group (-N=N-) connecting two aromatic systems. One system is a benzene ring substituted with a sulfonate group (-SO<sub>3</sub>H) and a chlorine atom. The other system is a benzene ring substituted with a sulfonate group (-SO<sub>3</sub>H) and an amino group (-NH<sub>2</sub>). Additionally, there is a side chain containing a sulfonate group (-SO<sub>3</sub>H) and a sodium ion (Na<sup>+</sup>).</p>



**Plate I**

**Selected dye for decolourization**

### 3.2 Preparation of dye solution

The Corafix Yellow dye solution were prepared by dissolving dye in deionized water to the required concentration. 0.01g of Corafix yellow dye powder was dissolved in 100 ml of water to prepare the dye solution for experimental process.



**Plate II**

**Prepared dye solution**

### 3.3 collection of agro waste

Ten different agricultural wastes including Egg shell, Bamboo leaf, Rice husk, Rice straw, Tapioca, Garlic peel, Corn cob, Corn husk and Wheat straw were selected for the present study. The selected agro wastes were air carried and ground into powder and sieved. The samples were then stored in a separate airtight polythene container for further analysis.



**Plate III (a) Raw agro waste (corn cob) (b) grounded agro waste (corn cob)**

**Selected adsorbents for the decolourization of selected dye**

### 3.4 Decolourisation process

The dye solution containing 0.01% of Corafix Yellow dye powder was taken in ten different beakers. The selected agro wastes were added in the concentration of 1.2 in the 0.1g of dye solutions separately for decolorizing process. The solution was kept at room temperature for 48 hours and the samples were filtered and the absorbance was measured at 426nm using UV-Vis spectrophotometer. Among the selected agro wastes maximum decolourization was found with corn cob as adsorbent.

Percentage decolourisation was calculated using the following formula;

$$\text{Percentage decolourisation} = \frac{C_0 - C_i}{C_0} \times 100$$

Where  $c_0$ ,  $c_i$  represents the initial and final absorbance at 426nm.

### 3.5 Optimization of various parameter for decolourization

The effect of different parameters including pH of the adsorbate solution, contact time and adsorbent dose on the decolorization of Corafix Yellow GD-3R using corn cob were investigated

#### 3.5.1 Effect of adsorbent dosages

Effect of adsorbent dosage on the removal of Corafix Yellow GD-3R were investigated by taking different concentrations of corn cob such as 0.2, 0.4, 0.8, 1.0, 1.2 and 1.4% with initial dye concentration of 0.01%. The experiment was conducted at room temperature for 48 hrs. The absorbance of dye solution was measured in UV-Vis spectrophotometer and the percent decolourisation was calculated.

#### 3.5.2 Effect of pH on dye adsorption

The adsorbate solution pH is a significant factor that may affect the decolourization process. The effect of pH on percent decolourization was investigated with the initial dye concentration of 0.01% and the adsorbent of 1.2 %. 0.1N HCl and 0.1N NaOH were used to adjust the pH values. The suspension were kept at room temperature for 48hours and percent decolourisation was determined.

### 3.5.3 Effect of adsorbate concentration

The influence of initial concentration of Corafix Yellow GD-3R in the solution on the rate of adsorption on corn cob was studied. The experiment was carried out at fixed adsorbent dose of 1.2% in 100ml at room temperature with different initial concentration of Corafix Yellow GD-3R (0.01 to 0.05) and decolourization % was assess after 48 hr

### 3.5.4 Effect of time

Effect of contact time on the adsorption of Corafix Yellow GD-3R was determined by maintaining dye aqueous solution, adsorbent dosage and time as constant while varying contact time as 6, 12, 18, 24, 30, 36, 42, 48, 54 hrs and decolourisation percentage was calculated.

### 3.6 Decolourization of selected dye solutions under optimized conditions

Corafix Yellow GD-3R was decolourized using corn cob (0.1%) at optimum dye concentration of 0.01 for 48 hrs at room temperature.



**Control and decolourized solution for Corafix Yellow GD-3R**

**Plate IV**

**Decolourization of selected dye solution using selected adsorbent under optimized condition**

### 3.7 Characterization of decolourized solution

Characterization refers to the broad and general process by which a materials structure and properties are probed and measured. Experimental characterization refers to the determination of the material properties through tests conducted on suitably designed specimen.

### **3.7.1 FTIR analysis**

Fourier Transform Infrared Spectroscopy, also known as FTIR analysis is a technique used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas. An FTIR spectrometer simultaneously collects high resolution spectral data over a wide spectral range. A common FTIR spectrometer consists of a source, interferometer, sample compartment, detector, and amplifier and A/D convertor. The source generates radiation which passes the sample through the interferometer and reaches the detector. Then the signal is amplified and converted to digital signal by the amplifier and analog-to-digital converter, respectively. Eventually, the signal is transferred to a computer. FTIR analysis was carried out for both dye solution and decolourized solution.

### **3.7.2 SEM analysis**

Scanning electron microscope (SEM) is one of the common methods for imaging the microstructure and morphology of the materials. In SEM, an electron beam with low energy is radiated to the material and scans the surface of the sample. It is one of the most widely used instrumental methods for the examination and analysis of micro- and nanoparticle imaging characterization of solid objects. SEM is used to determine the surface morphology of the corn cob, prior to the analysis the sample was degassed under vacuum and then mounted on adhesive carbon tape attached to an aluminum stub. SEM images of corn cob before and after adsorption was assembled

### **3.7.3 UV analysis**

Ultraviolet-Visible spectral field refers to absorption and it measures the span wavelengths from around 200 nm to 800 nm. The absorption by a molecule of ultraviolet or visible radiation results in transitions between the molecule's electrical energy levels. UV-vis spectroscopy is a cost-effective, simple, versatile, non-destructive, analytical technique suitable for a large spectrum of organic compounds and some inorganic species. As a function of wavelength, UV-vis spectrophotometers measure the absorption or transmission of light that passes through a medium. UV-Vis is a quick, convenient, and inexpensive way of determining the solution concentration. In UV-Vis, a beam travels through a solution in a cuvette with a wavelength ranging between 180 and 1100 nm. The sample absorbs this UV or visible radiation in the cuvette. The UV frequency is between 100 and 400 nm, and the visible spectrum is between 400 and 700 nm. UV spectrum was analyzed before and after decolourization of dye solution.

### 3.8 Reuse of decolourized dye solution

For the development of urban infrastructure, it is essential to have wastewater reuse for non-potable application since it will be very difficult to provide the huge water requirement for the developmental projects and the reuse of wastewater will not only save the money but also it retains the natural resources and helps to develop a sustainable environment (Bansal and Gill, 2017). Hence in the present study, an attempt was made to reuse the decolourized dye solution. The decolourized dye solution was used to dye selected cotton fabric with Corafix Yellow GD-3R.

#### 3.8.1 Selection of fabric

Cotton fabric is one of the most commonly used types of fabrics in the world. The cellulose in cotton fibers is also of the highest molecular weight among all plant fibers and highest structural order, highly crystalline, oriented and fibrillar. Cotton, with this high quantity and structural order of the most abundant natural polymer, is, not surprisingly, viewed as a premier fiber and biomass (Lo Hsieh, 2007). Hence, cotton fabric was chosen for the present study.

#### 3.8.2 Dyeing

A dye is an organic coloured compound which when applies to textiles for imparting colour and strictly adheres with the textile substrates. All dye is a colour substance whereas all colour substance are not dye (Imran, 2013). Dyeing is the application of the colourant to the substrate in order to enhance the appearance of the fabric, the selected cotton fabric was dyed with the Corafix Yellow GD-3R using decolourized and fresh water. The dyeing of cotton fabric with selected dye was carried with the following procedure.

**Table I**

**Procedure for dyeing with Corafix Yellow GD-3R**

Percentage of shade	2
M:L ratio	1:20
Temperature	100 <sup>0</sup> C
Time	1 hour

The dyeing was done using fresh water and decolourized water. The dyed fabrics were rinsed with cold water and dried in shade. The dyed fabrics were analyzed for physical and color fastness properties.

### 3.9 Phytotoxicity studies



(a) Green gram seedling with decolourized dye solution, dye solution and tap water



(b) Green gram seedlings on 7<sup>th</sup> day

#### Plate V

#### Growth of green gram seedlings

The toxicity of dye solution and decolorized solution was evaluated on germination of green gram (*Vigna radiata*). Germination experiments were carried out in coconut shell covered with mud in which three sets of ten seeds of green gram were germinated. The first set was moistened with distilled water, second set with dye solution and third with decolorized dye solution. The coconut shell that contain green gram seeds were kept at room temperature for 7 days. Germination of seeds were daily recorded. At the end of the germination experiment, the root length and shoot length of seedlings were measured.

$$\text{Germination percentage} = \frac{\text{Number of seeds Germinated}}{\text{Number of seeds Sown}} \times 100$$

$$\text{Vigour index} = \text{germination percentage} \times (\text{root length} + \text{shoot length})$$

### 3.10 Assessment of physical properties of dyed fabrics

It is important to test fabric properties throughout the production process, as part of quality control. Testing the fabric properties at regular intervals ensures that they are suitable for their intended purpose. The physical properties of fabric like fabric weight, fabric strength, fabric thickness, fabric elongation and fabric stiffness was to assess the performance of the fabric in conjunction with its end use.

### 3.10.1 Fabric Weight

Fabric weights are measured in a few different ways. Generally, the fabric weight is measured by weighing a standardized width of a yard or meter on a scale. Fabric weights are also occasionally determined by weighing square yards of quality, or by weighing yards per one pound. The weight of the one-yard or meter is recorded in ounces or grams and the fabric is then classified by its weight. Fabric GSM means the weight of fabric in grams in per square meter area. Specimen of known dimension are taken by a cutting device (GSM) cutter to obtain a consistent specimen size. It is a device used to cut circular specimen of 100 square centimeter of a fabric very accurately. It has 4 blades that cut the fabrics when the handle wheel is rotated by applying light pressure. Five specimen were selected from each fabric sample. Specimen selection should avoid taking samples from the fabric selvages



**Plate VI**  
**Fabric Weight**

### 3.10.2 Fabric Thickness

Fabric thickness is defined as perpendicular distance through the fabric, which determines the dimension between the upper and lower side of the fabric. Determination of thickness of fabric samples in laboratory is usually carried out with the help of a precision thickness gauge.

In Fabric Thickness Gauge, the fabric whose thickness is to be determined is kept on a flat anvil and a circular pressure foot is pressed on to it from the top under a standard fixed load. Then the Dial Indicator directly gives the thickness in mm.



**Plate VII**

**Fabric Thickness by Thickness Gauge**

**3.10.3 Fabric strength**

Tensile strength of fabric: when the stretching force is applied to the fabric, it begins to elongate. The stretching force increases gradually, elongation also increases, when the amount of stretching force reaches on a certain point, the fabric begins to break. That the tensile strength of the fabric is the amount of stretching force at which the fabric begins to break when it comes under stretching conditions. It is measured in Newton's per square centimeter or pounds per square inch. It depends upon the yarn strength, material type or thread count per square inch of the fabric etc. the tensile strength of the control and dyed fabrics were determined separately in the warp and weft direction.



**Plate VIII**

**Fabric Strength by Tensile Strength tester**

**3.10.4 Fabric stiffness**

4 testing specimens are prepared from each direction (warp and weft). The specimen size is kept 6" length & 1" width. The specimens are prepared by cutting the fabric with the help of a scissor. Each specimen is placed on a smooth platform. This platform has a low frictional coefficient. The edge of the

specimen to getting bend during the test is placed just over the edge of the platform where the sliding plate gets started. Now, the weighting plate is placed just over the test specimen. The front edge of the weighting plate is placed just over the specimen's front edge. Now, starts to push the weighting plate toward the sliding plate. The test specimen also slides with the weighting plate. The pushing of the specimen is carried out steadily and carefully. As the specimen comes out, it starts to hang. The pushing process gets continued. The specimen begins to bend due to its own weight. As the front edge of the specimen gets touched with a sliding plate, the pushing of the specimen is stopped immediately. Now travel the length of the specimen is recorded. This process is repeated for all remaining specimens to calculate the bending length and flexural rigidity.



**Plate IX**

### **Fabric Stiffness by Fabric Stiffness tester**

#### **3.10.5 Absorbency tests**

The absorbency of the fabrics is determined by the time the sample takes to absorb a fixed amount (usually a drop) of distilled or deionized water (Fan, 2008).

##### **3.10.5.1 Fabric Wicking**

The wicking or capillary pass method measures absorption. Five samples with a length of 15 cm and a width of 2.5 cm were cut. A glass rod placed on a heavy wooden block was taped to one end of the sample strip and a 2 gram weight was attached to the other end to maintain sample levels. At the weighed end, a 2 cm sample was dipped in a bowl of distilled water. The rise in water level on the strip was recorded by maintaining a time constant (1 minute). The same procedure was repeated for the other samples to calculate and record the average.

### **3.10.5.2 Fabric Sinking**

This includes a simple test of fabric wettability. In this test, a small square sample of about 1 "x 1" was cut and dropped onto the surface of the beaker. The time required for the sample to sink under the surface was observed. The shorter the time, the higher the wettability.

### **3.10.5 Colour Fastness Tests**

Color Fastness is the ability to keep original dye color under the influence of other kinds of external factors in the use processes of dyeing textiles. Color fastness refers to the resistance of color to fade or bleed of a dyed or printed textile materials to various types of influences e.g. water, light, rubbing, washing, perspiration etc. It is an important indicator to measure the quality of dyeing products.

#### **3.10.5.1 Fastness to sunlight**

The Color Fastness to light test is done by comparing the degree of fade of the sample after simulating sunlight with a standard color sample divided into eight grades; 8, as the resulting value, implies the best while 1 implies the worst light fastness. To test the fastness to sunlight of the dyed specimen cut 16cm\*5cm and divide them into 8 parts. The specimen of dyed fabrics was exposed to the direct sunlight the first portion was exposed from 7 day and the first portion was exposed for a day and the last portion was considered as standard and the comparison was done using grey scale and specimen was rated.

#### **3.10.5.2 Fastness to Washing**

Major loss of colour from the fabric is due to washing and results in staining over the adjacent fabric. Test sample of dyed fabric using fresh and decolourized water were cut by measuring 10\*10cm. Specimen were completely soaked in the soap solution, after that the samples were removed, rinsed in cold water thoroughly, squeezed well and dried. The same procedure was carried out for other dyed samp

## **RESULTS AND DISCUSSIONS**

## **4. RESULTS AND DISCUSSION**

The Results pertaining to the study “Adsorption of reactive dye Corafix Yellow GD-3R from aqueous solution using corn cob” is discussed under the following headings.

### **4.1 Screening of different adsorbents for decolourization of Corafix Yellow GD-3R in aqueous solution**

### **4.2 Optimization of various parameters for the decolourization of Corafix Yellow GD-3R dye**

4.2.1 Adsorbent dosage

4.2.2 Initial dye concentration

4.2.3 Time

4.2.4 pH

### **4.3 Optimized conditions for decolourization of Corafix YellowGD-3R**

### **4.4 UV-Vis spectral analysis**

### **4.5 FTIR (Fourier Transform Infra-Red) analysis**

### **4.6 Evaluation of dyed fabric**

4.6.1 Fabric Weight

4.6.2 Fabric Thickness

4.6.3 Fabric Strength

4.6.4 Fabric Stiffness

### **4.7 Absorbency**

4.7.1 Fabric Wicking

4.7.2 Fabric Sinking

### **4.8 Colour fastness**

4.8.1 Fastness to sunlight

4.8.2 Fastness to Washing

### **4.6 Phytotoxicity study**

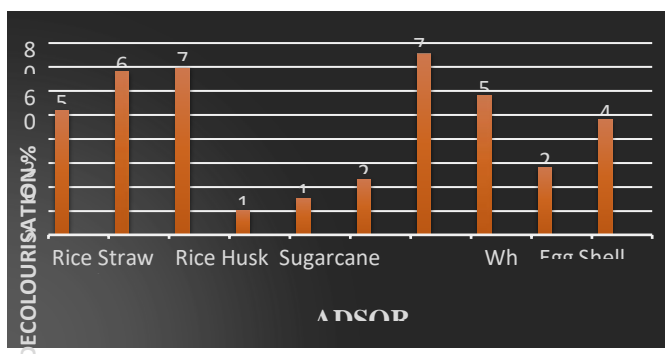
#### 4.1 Screening of different adsorbents for decolourization of Corafix Yellow GD-3R in aqueous solution

The decolourization efficiency of different adsorbents such as Rice Straw, Rice Husk, Sugarcane Bagasse, Bamboo Leaf, Tapioca Peel, Garlic Peel, Corn Cob, Corn Husk, Wheat Straw, Egg Shell were screened and results are presented in Table II and Figure 1

**Table II**

##### **Screening of selected adsorbents for the decolourization of selected Reactive dye**

<b>Adsorbents</b>	<b>Percent decolourization (%)</b>
Rice Straw	52
Rice Husk	68
Sugarcane Bagasse	70
Bamboo Leaf	10
Tapioca Peel	15
Garlic Peel	23
<b>Corn Cob</b>	<b>75.8</b>
Corn Husk	48
Wheat Straw	58
Egg Shell	28



**Figure 1**

### **Screening of selected adsorbents for the decolourization of selected dye**

Among the selected adsorbents corn cob powder showed maximum decolourisation percentage for Corafix Yellow GD-3R. The percent decolourisation observed for Corafix Yellow is 75.8% followed by sugarcane bagasse (70%). Hence corn cob was selected as potent adsorbent for the decolourisation of selected dye.

Yashim et al., 2015 reported that corn cob treated with phosphoric acid was very effective for decolourization of reactive dye Remozal red 3BS dye from aqueous solution. Sonu et al., 2020 reported that the acid activation of corn cob biochar increased the percentage decolourization of real textile dye wastewater by about 10% and it has achieved maximum dye removal rate was about 98%.

## **4.2 Optimization of various parameters for the decolourization of selected dyes**

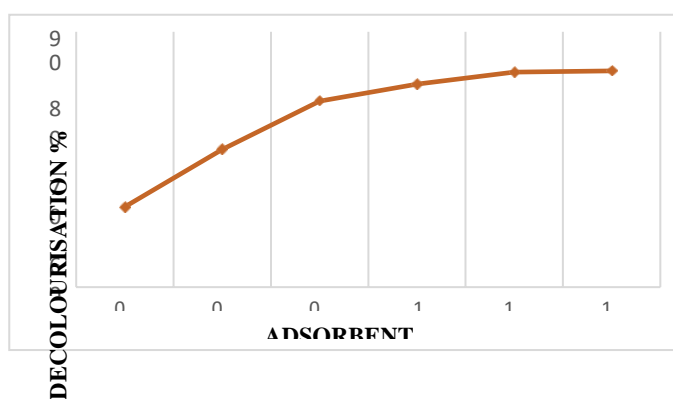
### **4.2.1 Adsorbent dosage**

The adsorbent dosage is an important parameter in order to determine the adsorbent's capacity for a given amount of the adsorbates at the operating conditions. The effect of adsorbent concentration for the decolourization of selected dye was studied and the results are presented in Table III and Figure 2

**Table III**

**Optimization of Adsorbent Dosage**

<b>Adsorbent Concentration (%)</b>	<b>Percent decolourization</b>
0.2	28.3
0.4	48.5
0.8	65.6
1.0	71.6
1.2	75.8
1.4	76.2



**Figure 2:** Effect of various adsorbent concentration on the adsorption of Corafix Yellow GD-3R onto corn cob

Table 3 and figure 5 clearly showed that the percent dye decolourisation, increases with increase in adsorbent concentration from 0.2 to 1.4. As there was no significant difference in % decolourisation between 1.2 and 1.4% adsorbent concentration. Maximum percent decolourisation was observed at 1.2 and 1.4 as 75.8, 76.2 but both shows the more or less same percentage of decolourisation so to minimize the usage of adsorbent 1.2g was taken as optimum dosage for decolourisation of Corafix Yellow GD-3R respectively fixed for further experiments.

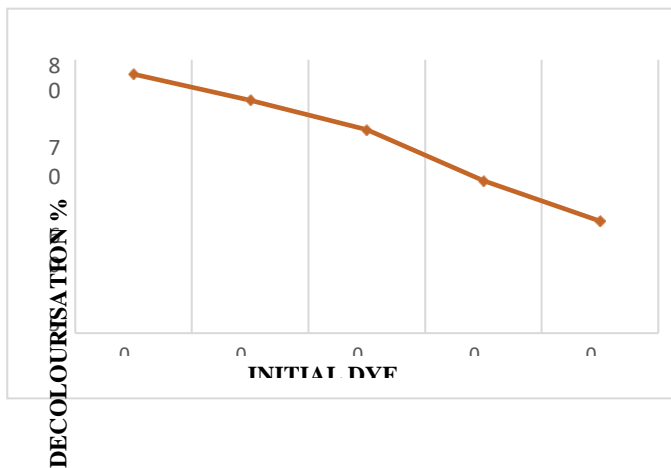
The increase in the rate of dye removal with increase in the dose of the adsorbent is due to the increase in the effective surface area making more sites accessible for adsorption (Sonu et, al, 2020). And an increase in the number of charged site available on the surface area of adsorbent (ETORKI and MASSOUD, 2011). The colour removal efficiency increased with an increase in adsorbent mass. This may be attributed to the availability of more adsorption sites and increasing pore surface areas with increasing adsorbent doses. It makes penetration of adsorbate molecules into the adsorption sites easier (Abdulsalam et al., 2020).

#### 4.2.2 Initial dye concentration

The dye removal efficiency is highly dependent on the initial dye concentration. The effect of the initial dye concentration on the decolourisation of selected dye was studied and the results are presented in Table IV and Figure 3

**Table IV**  
**Optimization of Initial dye concentration**

<b>Initial dye concentration (%)</b>	<b>Percent decolourisation</b>
<b>0.01</b>	<b>75.8</b>
0.02	68.2
0.03	59.5
0.04	44.6
0.05	32.8



**FIGURE 3** Effect of initial dye concentration on the adsorption of Corafix Yellow GD-3R

From Table 4 and Figure 3 it is clear that increase in initial dye concentration lowers the dye decolourisation percentage. Maximum dye removal was observed at an initial dye concentration of 0.01%. Hence initial dye concentration of 0.01% was fixed as optimum and used for further experiments.

Effect of changing the concentration of the dyes was investigated because it is essential to determine the threshold limit values of adsorption for possible application. In relation to this, adsorption experiment was carried out to get the equilibrium adsorption capacity and the removal efficiency of the dyes (Dahiru et al., 2018). At lower concentration of dye solution, the ratio of the initial number of dye molecules to the available surface area is low thus promoting the high adsorption at lower concentration (Yashim and salleh, 2015). On the other hand, the increase in initial dye concentration will cause an increase in the loading capacity of the adsorbent and this may be due to the high driving force for mass transfer at a high initial dye concentration (Bulut and Aydin, 2006).

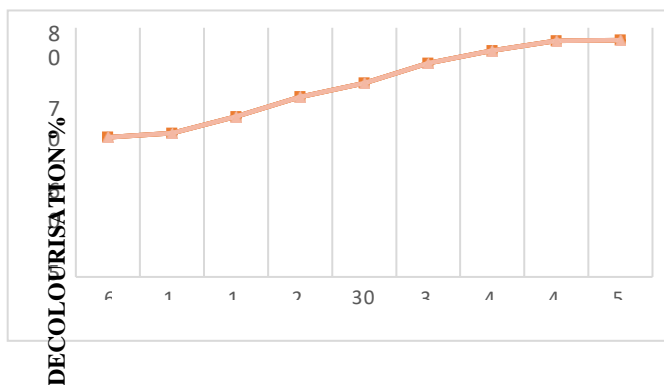
The capacity of the adsorbent material gets exhausted sharply with increase in initial dye concentration. This may be probably a result of the fact that for a fixed adsorbent dose, the total available adsorption sites remain invariable for all the concentrations checked. With increasing concentration the available adsorption sites become fewer and hence the percent removal of dye is dependent upon the initial dye concentration (Bharathi and Ramesh, 2013).

### 4.2.3 Time

In adsorption studies, contact time plays a vital role. Effect of contact time on decolourisation of selected dyes was examined at various time intervals such as 6, 12, 18, 24, 30, 36, 42, and 48 hours and the results are presented in Table V and Figure 4.

**Table V**  
**Optimization of**

<b>Time (hr)</b>	<b>Percent decolourisation</b>
6	42.28
12	49.3
18	51.4
24	57.4
30	62.1
36	68.3



**Figure 4:** Effect of various time on the adsorption of Corafix Yellow GD-3R onto corn cob adsorbent

The Table 5 and Figure 4 clearly indicates that maximum percent dye removal was achieved after 48 hours. When the contact time was increased above 48 hrs, there was no significant increase in (76%). Hence, an optimum time of 48hrs was selected for decolourisation studies.

The effect of contact time on adsorption of dye can be carried out by preparing adsorbate solution with fixed adsorbent dosage and initial dye concentration for different time intervals and allow them to decolourized under fixed temperature without any disturbance. Generally the rate of removal of dye increase with an increase in contact time to a certain extend (Parab et al, 2009). At the beginning, the surface area of activated carbon has not yet occupied. The rate of adsorption of dye ions by the exterior surface was fast initially. Once the exterior surface occupied by the dye ion and saturated, the dye ions entered into the pores were adsorbed by the interior surface of the particle (Yashim et al., 2015).

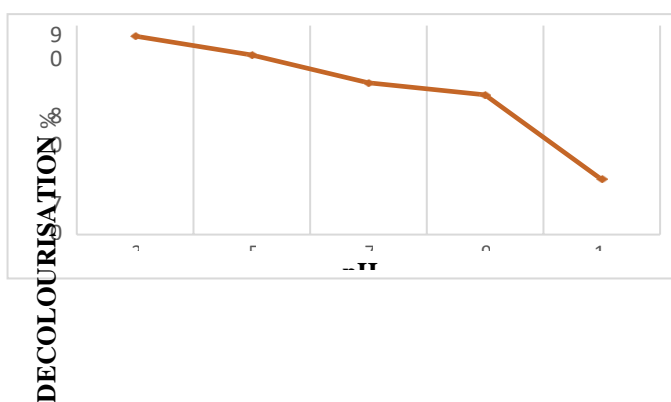
This is due to the availability of a large surface area in the initial stages of adsorption in comparison to the density of dye cations, which facilitates a high rate of adsorption. However, with increasing contact time, there is an increase in the surface coverage leading to competition among dye cations for the adsorption sites. This slows down the interaction between the dye cations and adsorbent surface (Parab et al.,

#### 4.2.4 pH

pH is an important parameter in the adsorption process, particularly for dye adsorption. Effect of PH on decolourisation of selected dye was examined at various pH such as 3, 5, 7, 9, and 10 and the result are represented in Table VI and Figure 5.

**Table VI**  
**Optimization of**  
**pH**

pH value	Percent decolourization %
3	85.5
5	77.3
7	65.4
9	60.2
10	23.7



**Figure 5:** Effect of various pH on adsorption of Corafix Yellow GD-3R onto corn cob adsorbent

From Table 6 and Figure 5 it is clear that, percent decolourisation was maximum at pH 3 for Corafix Yellow dye. This might be due to the anionic dye adsorption which increases at low pH because the adsorbent is acting as a positively charged surface. Hence PH of 3 was selected as optimum PH for decolourisation of Corafix Yellow GD-3R.

The pH of the solution has profound impact on the uptake of adsorbate molecules presumably as a result of its influence on the surface properties of the adsorbent material and ionization or dissociation of the adsorbate molecules (Dahiru et al, 2018). The pH factor is very important in the adsorption process especially for dye adsorption. The pH of a medium will control the magnitude of electrostatic charges which are imparted by the ionized dye molecule (Onal et al., 2006).

### 4.3 optimized conditions for decolourization of Corafix YellowGD-3R

The optimized condition for decolourization of Corafix Yellow was given in the following Table VII

**Table VII**  
**Optimized**  
**conditions**

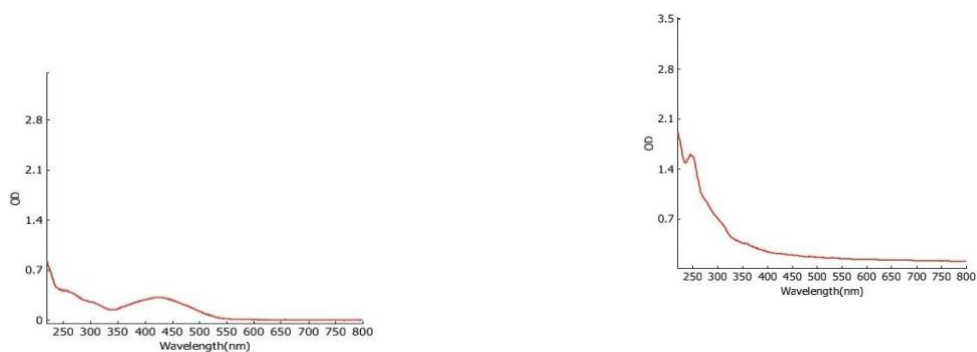
Parameters	Optimized conditions
Adsorbent dosage	1.2 %
Initial concentration	0.01 %
Time	48 hr
pH	3

The decolourization using corn cob was effective with 1.2% adsorbent dosage, 0.01 dye concentration, pH 3 and 48 hr.

### 4.4 UV-Vis spectral analysis

Spectrophotometric analysis of dye solution is taken before and after decolourisation of Corafix Yellow dye solution. The spectrophotometric analysis shows that the reactive dye solution has maximum absorbency at a visible range of 423nm. The decolourized dye solution shows maximum absorbency and 245nm at spectrophotometric analysis.

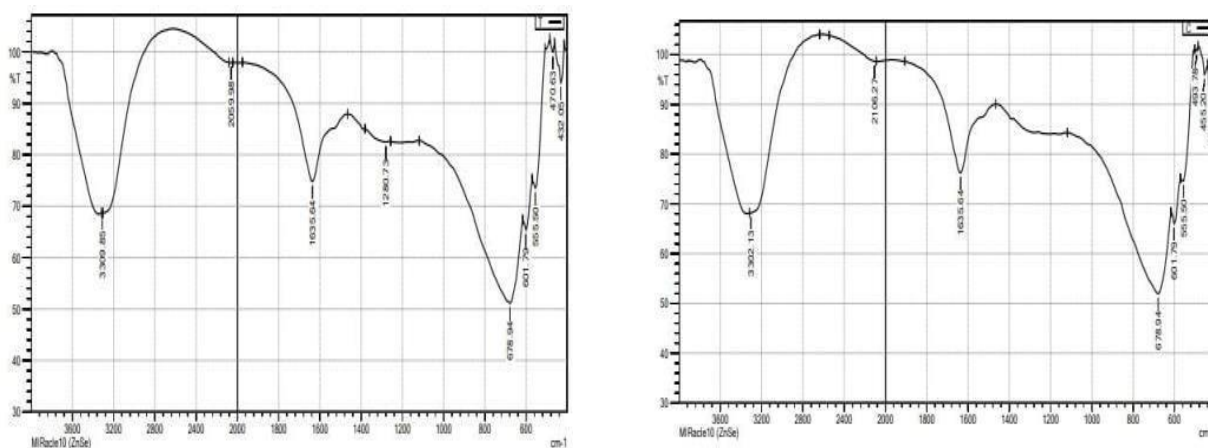
The dye removal is attributed to the degradation when the major visible light absorbance peak would be completely disappear or a new peak will appear (Battacharya and sarma, 2003). Results indicate that the peaks in the visible region have been shifted to UV region which rules the degradation of the dye by the adsorbent and the results are presented in Figure 6



**Figure: 6** (a) UV-Vis spectrum on solution Corafix Yellow GD-3R dye solution (b) UV-Vis spectrum on decolourized dye

#### 4.5 FTIR (Fourier Transform Infra-red) analysis

FTIR analysis was performed to identify the specific functional groups present in treated and untreated dye solution. FTIR spectrum studies were performed before and after decolourization to analyze the changes that took place in the Corafix Yellow GD-3R dye solution. The FTIR data of the dye solution before and after decolourization process are depicted in Table VIII and Figure 8 indicates the disappearance and shift of some peaks which may be due to the decolourization



**Figure: 7** (a) FTIR spectrum of reactive solution Corafix Yellow GD-3R dye solution (b) FTIR spectrum of decolourized dye

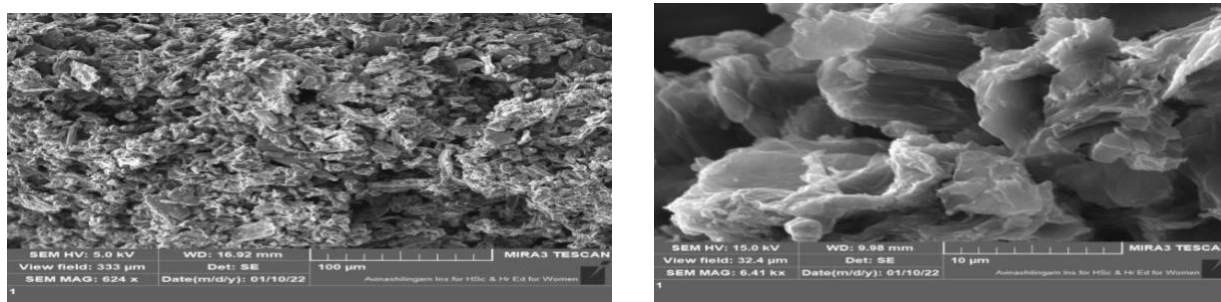
**Table VIII**  
**FTIR dye solution before and after decolourization**  
**process**

Frequency (cm <sup>-1</sup> ) Corafix Yellow GD-3R Pre adsorption	Post adsorption	Shift	Functional group assigned
3302	3309	7	N-H Stretching
2105	2059	46	N=C=S Stretching
1280	-	-	C-O Stretching
455	470	15	C-I
424	432	8	C-I

The disappearance of the band at 1280 cm<sup>-1</sup> confirms the decolourization of dye solution. The shift of the peak 3309 and 2059 to 3302 and 2105 shows N-H stretching and N=C=S stretching the higher frequency occurred due to removal of dye molecules in solution which resulted in stretching and weakening of bonds

#### 4.6 SEM (scanning electron microscope) analysis

The surface of corn cob before and after adsorption of reactive Corafix Yellow GD-3R was studied using the scanning electron microscope, and they are shown figure 8. It was clear from the observations that the raw corn cob had numerous pores and improved binding sites. These corn cob properties may favor dye molecule adsorption on its surface of the corn cob. However the surface of the corn cob was observed to be smooth after adsorption of dye molecules



(a) SEM image of Corn cob before decolourisation (b) SEM image of corn cob after decolourisation

**Figure: 8** SEM analysis on corn cob surface area in dye solution and decolourized solution

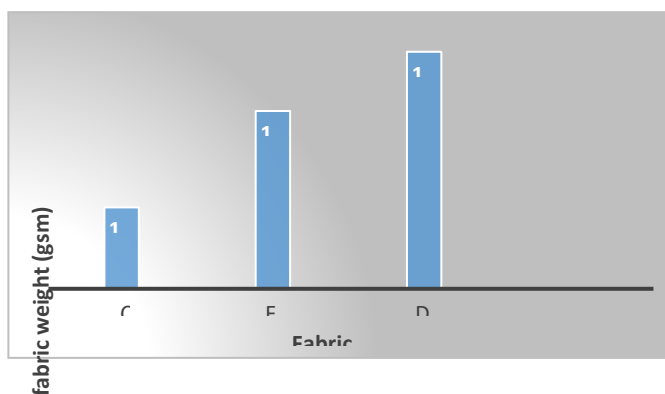
## 4.7 Evaluation of dyed fabric

### 4.7.1 Fabric weight

The fabric weight of the control fabric (C), fabric dyed with Corafix YellowGD-3R (FCY), using fresh water and fabric dyed with Corafix YellowGD-3R using decolourized water (DCY) are permitted in Table IX Figure 9

**Table**  
**Fabric weight**

S.No	Samples	Mean (GSM)	Loss /gain	Loss/ Gain%
1	C	1.31		
2	FCY	1.44	0.07	5.38
3	DCY	1.52	0.21	16.03



**Figure: 9** Fabric weight (gsm)

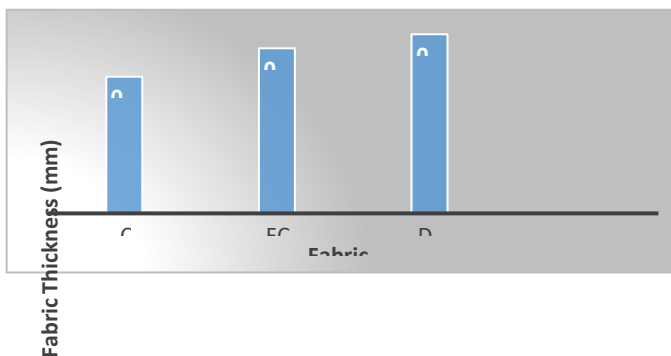
From the Table 8 and Figure 9 it is clear that the weight of the dyed samples increased when compared to the original fabric. The percent increase was found to be maximum in fabric dyed using decolourized water. Hence decolourized water can be used for dyeing purposes

### 4.7.2 Fabric Thickness

The fabric thickness of the control fabric (C), fabric dyed with Corafix YellowGD-3R (FCY), using fresh water and fabric dyed with Corafix YellowGD-3R using decolourized water(DCY) are permitted in Table X and Figure 10

**Table X**  
**Fabric thickness**

Table X S.No	Samples	Mean (mm)	Loss /gain	Loss/ Gain%
1	C	0.29		
2	FCY	0.35	0.06	20.6
3	DCY	0.38	0.09	31.03



**Figure: 10** Fabric Thickness (mm)

From the Table 9 and Figure 10 it is clear that the Thickness of dyed samples increased when compared to the original fabric. The percent increase was found to be maximum (31%) in fabric dyed using decolourized water. The increase in thickness may be attributed to increased uptake of dye.

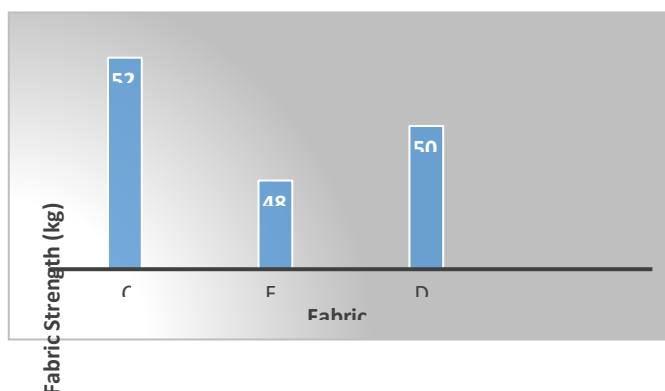
### 4.7.3 Fabric strength

The fabric strength and analysis of variance of the Control fabric (C), fabric dyed with Corafix YellowGD-3R (FCY), using fresh water and fabric dyed with Corafix YellowGD-3R using decolourized water (DCY) are permitted in Table XI and Figure 11

**Table XI**

**Fabric Strength**

S.No	Samples	Mean (kg)	Loss /gain	Loss/ Gain%
1	C	52.20		
2	FCY	48.60	3.6	51.26
3	DCY	50.20	2.0	51.24



**Figure 11** Fabric Strength (kg)

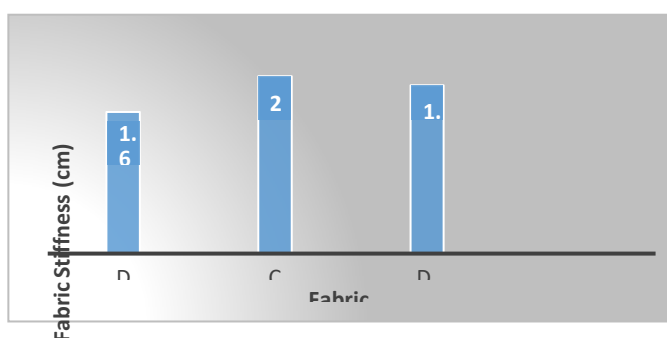
From the Table 10 and Figure 11 it is clear that the strength of all the dyed samples increases when compared to the original fabric. The percent increase was found to be similar in both the dyed fabrics. Hence decolourized water can be used for dyeing purposes

#### **4.7.4 Fabric Stiffness**

The fabric stiffness of the control (C), fabric dyed with Corafix YellowGD-3R (FCY), using fresh water and fabric dyed with Corafix YellowGD-3R using decolourized water (DYC) are permitted in Table XII and Figure12

**Table XII  
Fabric Stiffness**

S.No	Samples	Mean (cm)	Loss /gain	Loss/ Gain%
1	C	1.6		
2	FCY	2.0	0.4	25.1
3	DCY	1.9	0.3	19



**Figure 12** Fabric Stiffness (cm)

From the Table 11 and Figure 12 it is clear that the stiffness of the dyed fabrics was found to be increased when compared to the control fabric. The increase in stiffness might be due to dye uptake and maximum increase was noticed in fabric dyed using fresh water.

#### **4.8 Absorbency test**

The pressure required to force water through a fabric may be determined and the information used in the assessment of the fabric ability to do a particular job

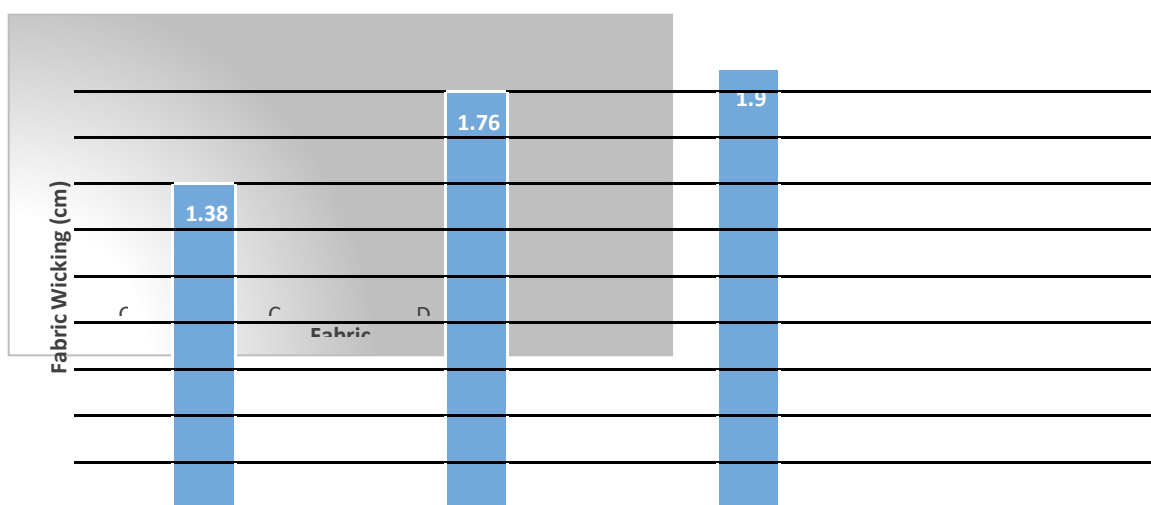
##### **4.8.1 Fabric Wicking**

The results of fabric wicking in control (C) and fabric dyed with Corafix YellowGD-3R (CY) using fresh water and decolourized water (DCY) are permitted in Table XIII and 13

**Table XIII**

**Fabric  
Wicking**

S.No	Samples	Mean (cm)	Loss /gain	Loss/ Gain%
1	C	1.38		
2	CY	1.76	0.38	27.5
3	DCY	1.90	0.52	37.69



**Figure 13** Fabric Wicking (cm)

From the above Table 12 and Figure 13 it is clear that the wicking of the dyed samples increased when compared to their control fabric. Fabric dyed using treated water exhibited higher absorbency (wicking) when compared to the fabric dyed using fresh water and control fabric

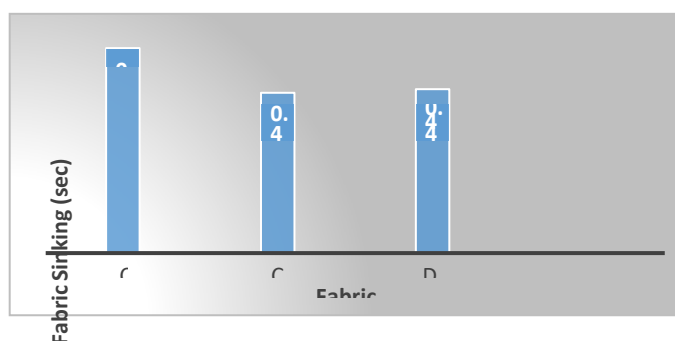
**4.8.2 Fabric sinking**

The results of fabric sinking of the sample of the control (C), fabric dyed with Corafix YellowGD-3R (CY), using fresh water and decolourized water (DCY) are given below table XIV and Figure 14

**Table XIV**

**Fabric  
Sinking**

S.No	Samples	Mean (sec)	Loss /gain	Loss/ Gain%
1	C	0.55		
2	CY	0.43	0.12	21.8
3	DCY	0.44	0.11	20.0



**Figure 14** Fabric sinking (sec)

From the above Table 13 and Figure 14 it is clear that the time taken for Sinking of the dyed samples decreased when compared to their control fabrics. The sinking time of the dyed samples using tap water and decolourized water was found to be on par with each other.

From the above absorbency tests can be concluded that absorbency was found to be increased in dyed fabrics.

#### **4.9 Colour fastness test**

The results of colour fastness tests to washing and sunlight of fabrics dyed using tapwater and decolourized water are presented in the Table XV

**Table XV**  
**Colour Fastness**

<b>Samples</b>	<b>washing</b>	<b>sunlight</b>
CY	4	4
CDY	5	5

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

With regard to colour fastness to washing, fabric dyed using tap water showed good fastness whereas fabric dyed with decolourized water showed excellent fastness. With regard to colour fastness to sunlight, , fabric dyed using tap water showed good fastness whereas fabric dyed with decolourized water showed excellent fastness

#### **4.10 Phytotoxicity study**

The results of germination percentage, root length, shoot length, of green gram seedling grown with tap water, treated reactive dye solution and Untreated reactive dye solution are depicted in Table XVI.

**Table XVI**  
**Phytotoxicity studies on green gram**

<b>Test</b>	<b>Shoot length(cm)</b>	<b>Root length(cm)</b>	<b>% Germination</b>	<b>Vigour index</b>
Plants watered with tap water	14	2.0	80	1280
Plants watered with decolourized Corafix Yellow solution	13.5	1.8	75	1147.5
Plants watered with reactive Corafix Yellow solution	6.2	0.5	45	301.5

A maximum of 80 percent germination was recorded in green gram seeds grown with tap water followed by 75 percent with treated Corafix Yellow and 45 percent with Corafix Yellow dye solution. The Vigour index was maximum for seedlings watered with tap water (1280)

## **SUMMARY AND CONCLUSION**

## 5. SUMMARY AND CONCLUSION

Synthetic dyes are potential carcinogenic, mutagenic and clastrogenic to living creatures, so they create significant water and soil contamination. The global population has been increasingly aware of the environmental and health risks of synthetic dyes over the last two decades. As a result, environmental and regulatory regulations governing the removal of these pollutants from industrial waste waterways are becoming increasingly strict. For the treatment of wastewater generated by the textile industries, many physical and chemical approaches have been used. These systems have numerous drawbacks, including high costs, low efficiency, limited adaptability, and the generation of secondary pollutants. Adsorption, on the other hand, is a cost- effective, efficient, biocompatible and ecologically acceptable approach for removing colours from industrial waste fluids. This research focused on using agricultural wastes to decolourize textile dye solutions because they are cheap, effective, and mostly eco-friendly. Adsorption techniques are commonly used to decolourize colour solutions made from agricultural waste.

### Experimental Procedure

Agricultural wastes like rice straw, sugarcane bagasse, rice husk, bamboo leaf, Tapioca peel, garlic peel, corn cob, maize husk, wheat straw, and egg shell are utilized in this procedure to turn non-eco-friendly solutions into eco-friendly solutions. The effect of various physico-chemical experimental conditions that affect dye adsorption, such as solution pH, initial dye concentration, contact time, adsorbent dose and temperature were investigated. To check the reusability of decolourized solution under optimized conditions. Decolorization of reactive azo dye Corafix Yellow GD-3R using corn cob was carried out.

To characterize the dye solution it was subjected to UV-Vis spectral analysis, FT-IR spectral analysis. Surface morphology of corn cob before and after dye adsorption was analyzed using SEM Tap water and decolorized water were used to dye cotton fabric. The dyed fabrics were analyzed for several physical attributes such as fabric weight, thickness, strength, stiffness, elongation, and colour fastness. To access the phytotoxicity of the decolourized solution, green gram was grown using decolourized solution. The biometric parameters include germination percentage, shoot length, root length and Vigour index was determined after 7 days. The result were compared with fresh water and untreated water.

## Findings

- Among the selected agro wastes, corn cob showed the highest percent of decolorization of Corafix Yellow dye solution. Hence it was selected for the study.
- The optimum concentration of corn cob was found to be 1.2 percent
- Effect of initial dye concentration on percent decolorization was analyzed the result showed that dye concentration on adsorption efficiency was declined. The percent decolourized was found to be maximum in 0.01 percent initial concentration. Hence it fixed for study.
- Effect of time on percent decolorization was found to be maximum at 48 hr and further increase in time, adsorption sufficiency remains constant.
- Corn cob adsorption capability was greatest at pH 7 (85.5 percent). The adsorption % gradually reduced when the pH was raised.
- UV-Vis spectrum of Corafix Yellow dye solution showed largest peak at 423nm, whereas in decolorized solution, it is at 245nm, indicating that the visible peaks have been moved to the UV region, which governs dye breakdown by the adsorbent.
- After dye adsorption, FT-IR measurement revealed variations in vibration frequency in the spectrum. Peak intensification and shifting were recorded.
- The dye buildup within the adsorbent surface was confirmed by scanning electron microscopy.
- The physical properties of fabric dyed with decolourized water demonstrate that it can be utilized for dyeing.
- When compared to the untreated dye solution, the treated dye solution containing corn cob showed germination percentage and growth characteristics such as shoot length, root length, and fresh weight. On the seventh day following seeding, plants grown with untreated dye showed the least amount of growth when compared to treated solution and tap water plants.

## **Conclusion**

From this study, it can be concluded that corn cob can be used as potent adsorbent to decolorize the Corafix Yellow GD-3R dye. The selected agro waste possess high absorbency at 1.2 percent. The investigation on dyeing on cotton fabric revealed that the treated dye solution can be utilized for dyeing and phytotoxicity studies on green gram showed that growth of plants was not affected with decolourized solution which indicate that the decolourized solution may be used for agricultural purpose also.

## **BIBLIOGRAPHY**

## 6. BIBLIOGRAPHY

- Abdulsalam, K. A., Giwa, A. R. A., & Adelowo, J. M. (2020). Optimization studies for decolourization of textile wastewater using a sawdust-based adsorbent. *Chemical Data Collections*, 27,
- Abinaya, S., Shanthini, D., & Grija, S. (2016). Color Removal from Textile Effluent Using Agro Adsorbent—A Review. *Int. J. Civil Eng. Technol*, 7, 278-281.
- Al-Gheethi, A. A., Azhar, Q. M., Senthil Kumar, P., Yusuf, A. A., Al-Buriahi, A. K., Radin Mohamed, R. M. S & Al-shaibani Muhanna Mohammed. (2022). Sustainable approaches for removing Rhodamine B dye using agricultural waste adsorbents: A review. *Chemosphere*, 287, 132080.
- Anjaneyulu, Y., Sreedhara Chary, N., & Samuel Suman Raj, D. (2005). Decolourization of industrial effluents—available methods and emerging technologies—a review. *Reviews in Environmental Science and Bio/Technology*, 4(4), 245-273.
- Ardila-Leal, L. D., Poutou-Piñales, R. A., Pedroza-Rodríguez, A. M., & Quevedo-Hidalgo, B. E. (2021). A brief history of colour, the environmental impact of synthetic dyes and removal by using laccases. *Molecules*, 26(13), 3813.
- Arumugam, A., & Saravanam, M. (2015). Adsorption of congo red dye from aqueous solution onto a low-cost natural orange peel and groundnut shell powder. *Der Pharmacia Lettre*, 7(12), 332-337.
- Benkhaya, S., M'rabet, S., & El Harfi, A. (2020). Classifications, properties, recent synthesis and applications of azo dyes. *Heliyon*, 6(1), e03271.
- Berber-Villamar, N. K., Netzahuatl-Muñoz, A. R., Morales-Barrera, L., Chávez-Camarillo, G. M., Flores-Ortiz, C. M., & Cristiani-Urbina, E. (2018). Corn cob as an effective, eco-friendly, and economic biosorbent for removing the azo dye Direct Yellow 27 from aqueous solutions. *PLoS One*, 13(4), e0196428
- Boer, C. G., Obici, L., de Souza, C. G. M & Peralta, R. M. (2004). Decolorization of synthetic dyes by solid state cultures of *Lentinula (Lentinus) edodes* producing manganese peroxidase as the main ligninolytic enzyme. *Bioresource Technology*, 94(2), 107-112.
- Bonilla-Petriciolet, A., Mendoza-Castillo, D. I., & Reynel-Ávila, H. E. (Eds.). (2017). Adsorption processes for water treatment and purification (Vol. 256). Berlin/Heidelberg, Germany: Springer.

- Chandarana Helly<sup>1</sup> and Joshi Dhvani<sup>2</sup> (2019). Application of Agricultural Waste for the Adsorption of Textile Colorant: A Review in International Research Journal of Engineering and Technology (IRJET), (Vol. 6).
- Muntaka Dahiru<sup>1,\*</sup>, Zakariyya Uba Zango<sup>2</sup>, Maje Alhaji Haruna<sup>3</sup> (2018). Cationic Dyes Removal Using Low-Cost Banana Peel Biosorbent. American Journal of Materials Science, 8(2): 32-38
- Etorki, A. M., & Massoudi, F. M. (2011). The use of peanut hull for the adsorption of colour from aqueous dye solutions and dye textile effluent. Oriental Journal of Chemistry, 27(3), 875.
- Hao, O. J., Kim, H., & Chiang, P.C. (2000). Decolorization of Wastewater. Critical Reviews in Environmental Science and Technology, 30(4), 449–505.
- Hettige, A. I., & Mowjood, M. I. M. (2015). Reduction of colour in treated wastewater from textile industry using sawdusts as bio-sorbents.
- Hossain, M. A., & Hossain, M. L. (2014). Kinetic study of Malachite Green adsorption on used black tea leaves from aqueous solution. Int. J. Adv. Res, 2(4), 360-374.
- Hossain, M. A., Ali, M. M., & Islam, T. S. (2018). Comparative adsorption of Methylene Blue on different low cost adsorbents by continuous column process. International Letters of Chemistry, Physics and Astronomy, 77, 26-34.
- Hu, H., & Xu, K. (2020). Physicochemical technologies for HRPBs and risk control. In High-risk pollutants in wastewater (pp. 169-207). Elsevier.
- Kaur, H., & Sharma, G. (2015). Removal of dyes from textile industry effluent: a review. Int J Humanit Soc Sci, 2(4), 59-63.
- Jinendra, U., Bilehal, D., Nagabhushana, B., Kumar, A.P.J.H., 2021. Adsorptive removal of Rhodamine B dye from aqueous solution by using graphene-based nickel nanocomposite. Heliyon 7 (4), e06851.
- Kaliyan, N., & Morey, R. V. (2010). Densification characteristics of corn cobs. Fuel Processing Technology, 91(5), 559-565.
- Khulbe, K. C., & Matsuura, T. (2018). Removal of heavy metals and pollutants by membrane adsorption techniques. Applied water science, 8(1), 1-30.
- Komal Priya, (2022). Methods of textile dyeing. Reviews in Textile Dyeing.
- Muharrem, I. N. C. E., & Ince, O. K. (2017). An overview of adsorption technique for heavy metal removal from water/wastewater: a critical review. International Journal of Pure and Applied Sciences, 3(2), 10-19.

- Parab, H., Sudersanan, M., Shenoy, N., Pathare, T., & Vaze, B. (2009). Use of agro-industrial wastes for removal of basic dyes from aqueous solutions. *CLEAN–Soil, Air, Water*, 37(12), 963-969.
- Pinto, J., Cruz, D., Paiva, A., Pereira, S., Tavares, P., Fernandes, L., & Varum, H. (2012). Characterization of corn cob as a possible raw building material. *Construction and Building Materials*, 34, 28–33
- Rashed, M. N. (2013). Adsorption technique for the removal of organic pollutants from water and wastewater. *Organic pollutants-monitoring, risk and treatment*, 7, 167-194.
- Slama, H. B., Chenari Bouket, A., Pourhassan, Z., Alenezi, F. N., Silini, A., Cherif-Silini, H & Belbahri, L. (2021). Diversity of synthetic dyes from textile industries, discharge impacts and treatment methods. *Applied Sciences*, 11(14), 6255.
- Šmelcerović, M., Đorđević, D., Novaković, M., & Mizdraković, M. (2010). Decolorization of a textile vat dye by adsorption on waste ash. *Journal of the Serbian Chemical Society*, 75(6), 855-872.
- Sonu, K., Sogani, M., Syed, Z., Dongre, A., & Sharma, G. (2020). Enhanced decolorization and treatment of textile dye wastewater through adsorption on acid modified corncob derived biochar. *Chemistry Select*, 5(39),
- Thiagarajan, P., & Nalankilli, G. (2014). Effect of reactive dyes structure on light fastness. *Int J Eng Res Technol*, 3, 1593-1596.
- Üner, O., Geçgel, Ü., Kolancılar, H., Bayrak, Y.J.C.E.C., 2017. Adsorptive removal of rhodamine B with activated carbon obtained from okra wastes. *Chem. Eng. Commun.* 204(7), 772–783.
- Yusuf, M. (2019). Synthetic Dyes: A Threat to the Environment and Water Ecosystem. *Textiles and Clothing*, 11–26.
- Zango, Z. U. (2018). Cationic dyes removal using low-cost banana peel biosorbent. *American Journal of Materials Science*, 8(2), 32-38.

## **APPENDICES**

**APPENDICES**  
**ORIGINAL AND DYED FABRIC**  
**SAMPLE**



**Desized Fabric**



**Fabric dyed with Corafix Yellow GD-3R  
GD-3R Using fresh water**



**Fabric dyed with Corafix Yellow  
using decolourized water**