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Electrolysis Using Carbon Electrodes to Treat Textile Wastewater for Chemical Oxygen Demand, Turbidity and Colour

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Abstract: Large amounts of wastewater comprising stubborn dyes and other textile processing chemicals are often produced by textile factories. It has been shown that the effluents emitted from these enterprises have a significant pollution load (high dissolved solids, COD, color, and chloride content) and are not easily biodegradable. As a result, discharging untreated textile effluent has serious environmental consequences. Historically, biological procedures, adsorption, the membrane process, and chemical coagulation have all been utilized to treat actual textile effluent. It has become more difficult to use conventional technologies to treat high-strength and complicated textile effluent. The idea, history, and several industrial uses of electro coagulation therapy, including optimization, modeling, combination composition, and comparisons to other treatment methods, are described and discussed in detail in this paper.

Keywords: coagulation, electrochemical treatment, electro coagulation, electrode, wastewater treatment

Introduction

Dyestuffs are found in the wastewater of many different sectors, including the textile, leather, pulp and paper, printing, picture, cosmetic, pharmaceutical, and others. These businesses generate substantial quantities of wastewater, which may include several compounds that are themselves very dangerous contaminants. In India, cities suffer from poor sanitation and wastewater management because of inadequate facilities. Because of inadequate wastewater treatment infrastructure, the quality of water resource has declined. Public health is negatively impacted when water quality declines. All perpetual aquatic resources may become unusable as a consequence of fast population growth and the resulting increase in wastewater production. In the future, not all of the wastewater from cities will be treated. Research on the generation and treatment of wastewater in class I cities (those with populations above 100,000) and class n towns was conducted by the Central Pollution Control Board (population between 50,000 and 100,000). According to the most recent research, the 921 Class I and Class n municipalities in hidia produce around 26254 million liters per day of wastewater. The demand for manufactured products is expected to rise in tandem with the global population. Thus, industrial trash is anticipated to increase at a rate higher than municipal garbage. There have been significant shifts in industrial wastewater management in recent years. Legislative obligations and technical progress are helping companies see the value of utilizing water for many uses, with decreasingly stringent purity standards, before releasing it into the environment. The greatest environmental negative impacts, leading to bio-system imbalance, are caused by wastewater created by numerous businesses.

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TEXTILE PROCESS AND NATURE OF EFFLUENT GENERATED	
Sizing	High BOD and COD
Desizing	High BOD, COD, suspended solids, dissolved solids
Scouring	Dark colored, high pH, high COD, dissolved solids
Bleaching	Alkaline, suspended solids
Mercerizing	High pH, low COD, high dissolved solids
Dyeing	Strongly colored, high COD, dissolved solids, low suspended solids, heavy metals
Printing	Highly colored, high COD, oily appearance, high suspended solids
Finishing	Slightly alkaline, low BOD

Figure 1. Characteristics of textile effluent generated from different processes

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Table 2. Characteristics of the textile industry effluent (All terms are in mg/*l* except pH and color)

Process	COD	BOD	TSS	TDS	pH	Color
Desizing	-	200	400	4029	6.8	-
Scouring	8000	100-2900	7.6-17.4	184-17400	7.3-13	694
Bleaching	1099	878	180	7132	8.5-9.6	153
Mercerising	1600	50-100	600-1900	4300-4600	5.5-9.5	-
Dyeing	23	11	37	-	8.35	1450-4750

Environmental Risk and Standards for Textile Effluent

The textile industry's effluent discharge is a major contributor to environmental degradation. Hence, legislation is needed to regulate the flow of industrial effluent into the natural environment. The textile industry's untreated effluent discharge has a significant influence on local water supplies. Effluent from the textile industry has a negative effect on the environment due to its high levels of chemical oxygen demand (COD) and biochemical oxygen demand (BOD5). Chemicals and heavy metals such as lead, mercury, arsenic, etc. are used in the dying and printing processes. There is a significant concentration of color, TDS, TSS, COD, BOD, and chloride in textile wastewater. For improved performance in the final textile, these sectors use the use of a wide range of chemicals (bleaching agents, salts, acids, alkalis, etc.). Dye molecules are large, they are structurally complicated, and they dissolve easily in water. Dyes have qualities that allow them to remain in an environment after being released. The textile effluent has a negative impact on aquatic life due to its high levels of COD, BOD, and oil-grease. Dissolved oxygen depletion in water raises the mortality rate of aquatic bodies and disrupts ecosystems. Wastewater from the textile industry is often turbid because the dyes and chemicals used in the industry make the water opaque. That's why it's bad for photosynthesis: (Sun et al., 2007). Heavy metals may be found in textile wastewater. Pollutants accumulate in the bodies of living things and then go up the food chain. That's why effluent from the textile industry is so dangerous. The Indian government's environmental watchdogs, the Ministry of Environment and Forest (MoEF) and the Central Pollution Control Board (CPCB), stipulate that textile factories must adhere to MINAS before discharging wastewater into the environment. Standard 6, 7, and 92 of schedule-I of the Environment (Protection) Regulations, 1986 detail the requirements for the textile industry. Table 2 displays the requirements set out by the Environment (Protection) Regulations, 1986 for the discharge of wastewater from textile businesses.

Methods for the Treatment of Textile Effluent

In reality, textile wastewater comprises a wide variety of complicated chemicals. Several different technologies, including physicochemical and biological treatments, have been developed over the last few decades in an effort to find a cost-effective way to clean up textile effluent.

Physico-Chemical Treatment Process

Chemical coagulation, adsorption techniques, and membrane filtration are some of the physico-chemical procedures used to remediate textile effluent. Although these techniques are very effective for hazardous wastewater, they are not favored for dealing with textile wastewater due to the latter's high concentrations of color and total dissolved solids. The cost of using these procedures to clean up textile effluent is high. Chemical oxidation requires the use of chemicals, which are both expensive and harmful to the environment. There is no mineralization of the pollutant particles during the adsorption process. The desorbed pollutants need to be treated, which adds to the expense of the adsorption mechanism. Membrane filtration is costly due to the high cost of membranes and membrane fouling. In addition, a significant downside of these physicochemical wastewater treatment procedures is the production of secondary contaminants. Disposing of treated wastewater requires further and tertiary treatments, as well as physicochemical treatment procedures.

Biological Treatment Processes

There are two types of biological therapy processes: aerobic and anaerobic. Bacteria play a crucial role in each of these processes. Activated sludge processing (ASP) and biofilm processing are examples of aerobic biological therapy. The COD and BOD mass flow of wastewater from the textile industry varies. The sensitivity of ASP to changes in COD and BOD is a serious issue, as is the accumulation of sludge. Large spaces are needed for ASP installations, and the system will need regular upkeep once it's up and running. Due to the non-biodegradability of dyes, the use of ASP to the wastewater treatment process for textiles is restricted. Textile wastewater is treated using a wide variety of anaerobic treatment techniques. Nevertheless, the decomposition of textile wastewater under anaerobic circumstances produces hazardous organic molecules, rendering anaerobic methods ineffective for its treatment. The proliferation of bacteria is hindered by these poisonous substances. Effluent dyes are not biodegradable, which is a problem with conventional treatment procedures, however modern electro-chemical techniques may solve this problem.

Electro-Chemical Treatment Methods

Electrochemical treatment is a novel approach of purifying water. Unlike chemical oxidation, electrochemical processes do not need the addition of chemicals to wastewater outside of the treatment facility. Secondary pollutants are not produced by electrochemical techniques of treatment. Electrochemical degradation relies heavily on the exchange of electrons between the treated material and the electrodes. Electrons are a green, clean reagent used in electrochemical wastewater treatment. Electro-chemical treatment procedures are very

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beneficial for pollution avoidance issues; as a result, this technology is safe for the planet. Electro-chemical treatment completely mineralizes organics due to the production of potent oxidizing agents. It's often referred to as a "green" approach of cleaning wastewater. Electrochemical treatment techniques provide a number of benefits, including high current efficiency, the ability to be automated, simple management, and operation under moderate environmental conditions (room temperature and air pressure). As the reaction may be started and stopped simply by switching on and off the electricity, electrochemical treatment procedures are very reliable. These technologies are quite flexible since they may be used to wastewater with a wide range of COD concentrations, from 0.1 to 100 g/l. Hence, electrochemical approaches are a viable alternative to traditional treatment methods when bio-refractory and hazardous contaminants are present. These are examples of the main excluded region in electrochemical treatment:

Table 2. Standard for Textile Effluent Discharge

Industry	Parameters	Standards
All integrated textile units, units of cotton/ woolen/ carpets /polyester, units having printing / dyeing / bleaching process or manufacturing and garment units.	Color, P.C.U (Platinum Cobalt Units)	150
	pH	6.5 to 8.5
	Suspended Solids (mg/l)	100
	BOD (mg/l)	30
	COD (mg/l)	250
	Total Chromium as (Cr) (mg/l)	2.0
	Sulphide (mg/l)	2.0
	Total residual chlorine (mg/l)	1
	Oil and grease (mg/l)	10
	Phenolic Compounds (mg/l)	1
	Inorganic (TDS) (mg/l)	2100
	Sodium Absorption Ratio (SAR)	26
	Ammonical Nitrogen (as N) (mg/l)	50

Source: Central pollution control board (CPCB), India

Literature Review

Million Ebba,et.al (2021) The presence of various contaminants in wastewater produced from various sources has an impact on the health of living creatures and the natural environment. Effluents from wastewater treatment plants that use electrocoagulation (EC) are safe for the environment. By adjusting the process's operational conditions, electrocoagulation may efficiently eliminate color, chemical oxygen demand (COD), turbidity, and energy use from wastewater..

Rafaela De Maman et.al (2021) Effluents from the dyeing of jeans with Indigo Blue, a dye often used in the textile mills, are notoriously difficult to treat because they include high concentrations of organic contaminants with resistant properties. Electrocoagulation is one of the several therapy modalities that has been the subject of much study. This method of

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therapy employs an electrochemical process that produces its own coagulant by means of the application of electric current on metallic electrodes.

Nabeela Firdous et.al.,(2021) The textile industry's wash-off procedures for dyeing are very water demanding, producing highly contaminated effluent. The electrocoagulation procedure was tested to see how well it decolored synthetic CI Reactive Yellow 145 effluent such that it could be reused in eight more rinse cycles of textile dying. Maximum color removal effectiveness (98%) was attained at pH 7, 10 minutes of treatment time, and 90 A/m2 of applied current density after optimizing the process parameters (Electrolysis duration, applied current density, and pH). Color contrast and wash fastness were used to evaluate the fabric quality. All colored fabric samples up to 8 reuse cycles had color difference values between 0.38 and 0.85, well within the range of acceptable quality in the industrial setting (Ecmc 1). The fabric samples' color retention and wash fastness were similar to those of fabrics that had been removed using standard washing procedures. The pH, COD, TDS, and turbidity all went up with each reuse, yet the quality of the dyeing never suffered. The electrocoagulation treated color wash-off liquid may be reused up to 8 times, making this method a sustainable option for the textile sector.

Materials and Methods

Textile wastewater collection and sampling

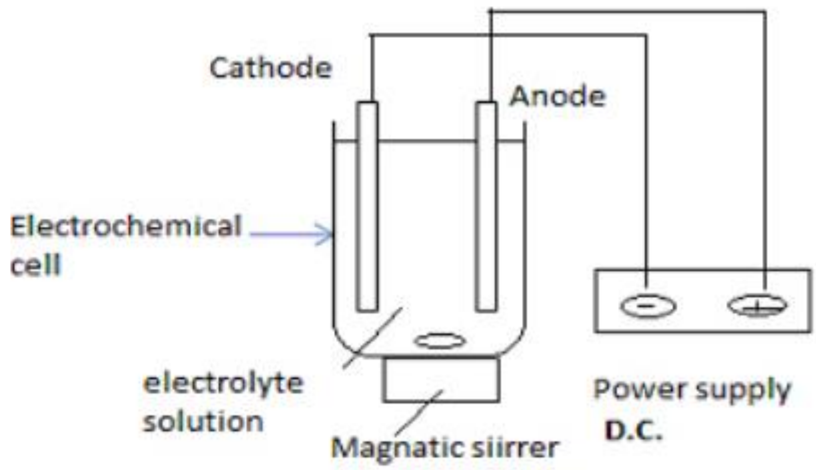

Figure 2: Experimental setup (Patel N Bet al, 2012)[14]

The anode and cathode of the electro coagulation setup, respectively. Figure 2 depicts the electrodes linked to a power source and submerged in the aqueous solution. Electrodes in the solution permit the flow of current. The anode and cathode of an electrolytic cell are two electrodes submerged in an electrically conductive solution (the electrolyte) and electrically coupled to one another and to an external current source and control device. Using aluminum and iron electrodes, he performed tests in an electro coagulation reactor. In the experimental factorial layout, the percentage of COD elimination served as a response variable. The procedure was affected by three variables: current strength, treatment time, and pH. At a pH of 8.2, 83% of the COD was removed, whereas at a pH of 7, 84% of the COD was removed, both with a current intensity of 7 A and a treatment period of 15 minutes. Nevertheless, values greater than 80% removal were found at 5 A and 10 min. According to the results, only the magnitude of the current and its duration were statistically significant predictors of the outcome. The study found suggested electro coagulation is a practical method for treating this wastewater, and that it is also more adaptable than biological procedures.

Effect of pH

The pH of the environment also plays a major role in determining how well contaminants are eliminated. Due to the increased release of ions and heightened metal dissolution, the metals anode becomes unstable and more reactive at low pHvalue. Metal ion release becomes more gradual at high values, decreasing color overall COD removal efficiency. Even though a lower pH is preferable, flocs do not develop at that level, therefore settling is not carried out effectively. The pH level has to be kept between for effective waste management (3-9)

Conclusion

Electrolysis using carbon bars and electrodes to remove COD, viscosity, and colour from textile effluent was the focus of this study. Carbon electrodes have been shown to be an effective coagulant because they generate coagulation factors inside the textile effluent. Carbon electrodes pose no threat to human health since metals do not precipitate out during the pollution clearing process. The electrolysis process was investigated in a wide variety of forms. It was shown that the voltage value affects the efficiency with which pollutants are removed, with large voltage values resulting in more efficient removal. Moreover, pH has a significant role in primary treatment, and electrode spacing plays a major role in percentage removal

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