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Dye Removal from Wastewater

Seroor Atalah Khaleefa Ali
Environmental Engineering, College of Engineering, Al-Mustansiriya University, Baghdad, Iraq

ABSTRACT

Wastewater treatment is a process used to convert wastewater into an effluent that can be either returned to the water cycle with minimal environmental issues or reused. Treatment means removing impurities from water being treated; and some methods of treatment are applicable to both water and wastewater. The physical infrastructure used for wastewater treatment is called a wastewater treatment plant. Dyes are widely used in industries such as textiles and others, to color their products. As a result, they generate a considerable amount of colored wastewater.
Keywords : Wastewater Treatment, Textile Wastewater Treatment, Decolorization

I. INTRODUCTION

The treatment of wastewater belongs to the overarching field of Public Works - Environmental, with the management of human waste, solid waste, sewage treatment, stormwater (drainage) management, and water treatment. Dyes are widely used in industries such as textiles, rubber, plastics, printing, leather, cosmetics, etc., to color their products. As a result, they generate a considerable amount of colored wastewater.

With the introduction of an oxidizing agent during chemical oxidation, electrons move from the oxidant to the pollutants in wastewater. The pollutants then undergo structural modification, becoming less destructive compounds. Alkaline chlorination uses chlorine as an oxidant against cyanide. However, alkaline chlorination as a chemical oxidation process can lead to the creation of toxic chlorinated compounds, and additional steps may be required. Advanced oxidation can help remove any organic compounds that are produced as a byproduct of chemical oxidation, through processes such as steam stripping, air stripping, or activated carbon adsorption.

Certain types of chemicals are used to clarify wastewater in primary industrial treatment. They are categorized as follows:
– pH adjustment chemicals
– Coagulant chemicals
– Flocculent chemicals

pH adjustment chemicals

Chemicals used in wastewater treatment to adjust pH serve to modify the ionic charge of the wastewater.

A definition of pH is an expression of the intensity of the basic or acidic condition of wastewater. Mathematically, pH is the logarithm (base 10) of the reciprocal of the hydrogen ion activity.

The pH is expressed numerically ranging above 0 thru 14. A pH or 7.0 is neutral and pH below 7.0 is acidic and pH above 7.0 is basic or alkaline.

Coagulant Chemicals
Coagulant chemicals are used in wastewater treatment to adjust pH and begin coagulating solids in the wastewater. Selecting chemicals to coagulant solids in the wastewater requires considering the chemical makeup of the wastewater.

Flocculent Chemicals
Flocculent chemicals are generally synthetic chemicals and have no effect on pH, however they are used in wastewater treatment to flocculate and separate solids from clarified wastewater.

Hydrogen Peroxide

Hydrogen peroxide (H2O2) has been used to reduce the BOD and COD of industrial wastewaters for many years. While the cost of removing BOD and COD through chemical oxidation with hydrogen peroxide is typically greater than that through physical or biological means, there are nonetheless specific situations which justify the use of hydrogen peroxide. These include: Predigestion of wastewaters which contain moderate to high levels of compounds that are toxic, inhibitory, or recalcitrant to biological treatment (e.g., pesticides, plasticizers, resins, coolants, and dyestuffs);

- Pretreatment of high strength / low flow wastewaters – where biotreatment may not be practical – prior to discharge to a Publicly Owned Treatment Works (POTW);
- Enhanced separation of entrained organics by flotation and settling processes; and
- Supply of supplemental Dissolved Oxygen (DO) when biological treatment systems experience temporary overloads or equipment failure.

As indicated by these examples, H2O2 can be used as a stand-alone treatment or as an enhancement to existing physical or biological treatment processes, depending on the situation.

Hydrogen peroxide can be used alone or with catalysts – such as iron (Fe2+ or Fe3+), UV light, ozone (O3) and alkali – to oxidize BOD/COD contributing compounds in wastewaters. The type of oxidation needed depends on the type of BOD/COD present. This relationship is present in the figure below.

If a large fraction of the BOD and COD is contributed by inorganic reduced sulfur compounds such as sulfides, sulfides, or thiosulfate, then hydrogen peroxide alone is typically effective. Depending on the wastewater pH, the oxidation of these compounds by H2O2 yields sulfate or colloidal sulfur, neither which contribute to BOD and COD.

	Chemical Oxygen Demand		
Oxidant System	Type A (Sulfide, Thiosulfate, Sulfite)	Type B (Phenols, Cyanides, Amines)	Type C (BTEX, TOCI, Paraffins)
Type A			
H2O2	X		
Type B			
H2O2 / OH-	X	X	
H2O2 / M+	X	X	
H2O2 / H+	X	X	
Type C			
H2O2 / Fe	X	X	X
H2O2 / O3	X	X	X
H2O2 / UV	X	X	X

Note: Whether an oxidant system will degrade a specific pollutant (i.e., affect its COD) will depend on the oxidant system and the pollutant. Type A oxidants react only with Type A pollutants; whereas, Type C oxidants, being more reactive, react with most any pollutant. However, Type C oxidants generally react preferentially with Type A pollutants.

If the primary contributors to BOD and COD are dissolved organics, then a more reactive oxidation system is needed. Moderate activation of hydrogen peroxide can be achieved by: 1) alkali (generating the perhydroxyl ion , OOH- – the active agent in peroxide bleaching systems); 2) certain transition metals (e.g., tungstate, vanadate, molybdate) which form reactive peroxometal complexes in-situ; and 3) certain mineral acids (e.g., sulfuric) which form reactive peroxyacid derivatives such as peroxymonosulfuric acid (Caro's Acid) ex-situ. For the more recalcitrant organics such as chlorinated solvents, extremely reactive free radical systems (termed Advanced Oxidation Processes) are needed. A generalized reaction using Fenton's Reagent for reducing BOD and COD can be expressed as follows:

The impact of untreated domestic wastewater on community reservoirs has raised several health and safety concerns. The organisms of concern in domestic wastewater include enteric bacteria, viruses, and protozoan cysts. disinfection has become one of the primary mechanisms for the inactivation/destruction of pathogenic organisms. In order for disinfection to be effective wastewater must be adequately treated.

Chlorine

Chlorine is the most widely used disinfectant for municipal wastewater because it destroys target organisms by oxidizing cellular material. Chlorine can be supplied in many forms, which include chlorine gas, hypochlorite solutions, and other chlorine compounds in solid or liquid form. Some alternative disinfectants include ozonation and ultraviolet (UV) disinfection. Choosing a suitable disinfectant for a treatment facility is dependent on the following criteria:

Ability to penetrate and destroy infectious agents under normal operating conditions.

Safe and easy handling, storage, and shipping.

Absence of toxic residuals and mutagenic or carcinogenic compounds after disinfection

Advantages and disadvantages

Chlorine is a disinfectant that has certain health and safety limitations, but at the same time, has a long history of being an effective disinfectant. Before deciding whether chlorine meets the municipality's needs, it is necessary to understand the advantages and disadvantages of this product.

Advantages

- Chlorination IS a well-established technology.
- Presently, chlorine is more cost-effective than either UV or ozone disinfection (except when dechlorination is required and fire code requirements must be met).
- The chlorine residual that remains in the wastewater effluent can prolong disinfection even after initial treatment and can be measured to evaluate the effectiveness.
- Chlorine disinfection is reliable and effective against a wide spectrum of pathogenic organisms.
- Chlorine is effective in oxidizing certain organic and inorganic compounds.
- Chlorination has flexible dosing control.
- Chlorine can eliminate certain noxious odors during disinfection.

Disadvantages

- The chlorine residual, even at low concentrations, is toxic to aquatic life and may require dechlorination.
- All forms of chlorine are highly corrosive and toxic. Thus, storage, shipping, and handling pose a risk, requiring increased safety regulations.
- Chlorine oxidizes certain types of organic matter in wastewater, creating more hazardous compounds (e.g., trihalomethanes [THMs]).
- The level of total dissolved solids is increased in the treated effluent.
- The chloride content of the wastewater is increased.
- Chlorine residual is unstable in the presence of high concentrations of chlorine-demanding materials, thus requiring higher doses to effect adequate disinfection.
- Some parasitic species have shown resistance to low doses of chlorine, including oocysts of Cryptosporidium parvum, cysts, of Endamoeba histolytica and Giardia Iamblia, and eggs of parasitic worms.
- Long-term effect of discharging dechlorinated compounds into the environment are unknown.

ECTIOUS AGENTS POTENTIALLY PRESENT IN UNTREATED DOMESTIC WASTEWATER

Organism	Disease Caused
Bacteria	
Escherichia coli	*Gastroenteritis*
Leptospira (spp.)	*Leptospirosis*
Salmonella typhi	*Typhoid fever*
Salmonella (=2100 serotypes)	*Salmonellosis*
Shigella (4 spp.)	*Shigellosis (bacillary dysentery)*
Vibrio cholerae	*Cholera*
Protozoa	
Balantidium coli	*Balantidiasis*
Cryptosporidium parvum	*Cryptosporidiosis*
Entamoeba histolytica	*Amebiasis (amoebic dysentery)*
Giardia lamblia	*Giardiasis*
Helminths	
Ascaris lumbricoides	*Ascariasis*
T. solium	*Taeniasis*
Trichuris trichiura	*Trichuriasis*
Viruses	
Enteroviruses (72 types) e.g., polio echo and coxsackie viruses)	*Gastroenteritis, heart anomalies, meningitis*
Hepatitis A virus	*Infectious hepatitis*
Norwalk agent	*Gastroenteritis*
Rotavirus	*Gastroenteritis*

Source: Adapted from: Crites and Tchobanoglous (1998) with permission from The McGraw-Hill Companies.

Dyes in Wastewater

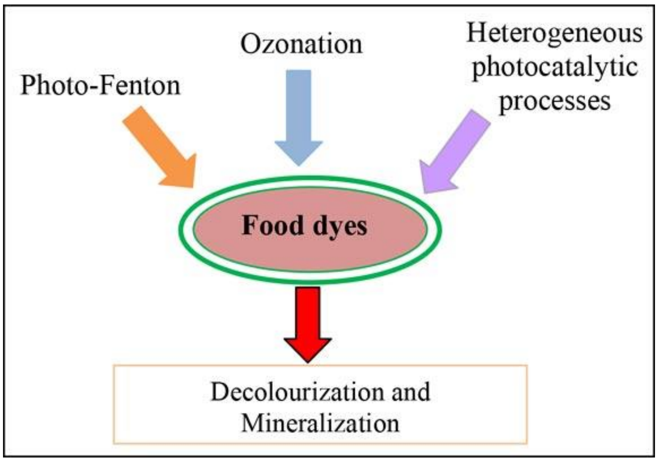
Dyes can have acute and/or chronic effects on exposed organisms depending on the exposure time and dye concentration. Dyes can cause allergic dermatitis, skin irritation, cancer, mutation, etc. Dyes can be classified as: anionic (direct, acid and reactive dyes), cationic (basic dyes) and non-ionic (dispersive dyes). Wastewater from dyeing processes in the textile industry is a considerable source of environmental contamination, and its treatment for decolorization and removal of dye substances represents a substantial part of the integral processes for industrial wastewater purification. The effluent from the dyeing is characterized by strong color, high pH, high COD, high temperature and low or no biodegradability. There are more than 10,000 dyes incorporated in the Colour Index and available commercially, most of which are difficult to decolorize due to their complex aromatic molecular structure and synthetic origin . One of the major factors determining the release of a dye into the environment is its degree of fixation on the fiber.

There are more than 10,000 commercially available dyes with over 7×10^5 tonnes of dye stuff produced annually. It is estimated that 2 % of dyes produced annually is discharged in effluents from associated industries. Among various industries, textile industry ranks first in usage of dyes for coloration of fiber. The total dye consumption of the textile industry worldwide is in excess of 107 kg/year and an estimated 90 % of this ends up on fabrics. Consequently, 1,000 tones/year or more of dyes are discharged into waste streams by the textile industry worldwide. Discharge of dye-bearing wastewater into natural streams and rivers poses severe problems to the aquatic life, food web and causes damage to the aesthetic nature of the environment.

Dyes absorb and reflect sunlight entering water and so can interfere with the growth of bacteria and hinder photosynthesis in aquatic plants. The problems become graver due to the fact that the complex aromatic structures of the dyes render them ineffective in the presence of heat, light, microbes, and even oxidizing agents and degradation of the dyes become difficult. Hence, these pose a serious threat to human health and water quality, thereby becoming a matter of vital concern. Keeping the essentiality of color removal, concerned industries are required to treat the dye-bearing effluents before dumping into the water bodies. Thus, the scientific community shoulders the responsibility of contributing to the waste treatment by developing effective dye removal technique.

Many treatment processes have been applied for the removal of dye from wastewater such as: Fenton process, photo/ferrioxalate system, photo-catalytic and electrochemical combined treatments, photo-catalytic degradation using UV/TiO_2, sono-chemical degradation, Fenton-biological treatment scheme, biodegradation, photo-Fenton processes, integrated chemical–biological degradation, electrochemical degradation, adsorption process, chemical coagulation/flocculation, ozonation, cloud point extraction, oxidation, nano-filtration, chemical precipitation, ion-exchange, reverse osmosis and ultra-filtration.

Acidic Azo dyes are used extensively in the last years in dying and textile industries, but they are environmentally hazardous and stated as carcinogenic. Discharge of these effluent in water supplies without sufficient treatment can cause to environmental and health hazards.



wastewater treatment is the process of removing contaminants from wastewater, primarily from household sewage. It includes physical, chemical, and biological processes to remove these contaminants and produce environmentally safe treated wastewater (or treated effluent). A by-product of sewage treatment is usually a semi-solid waste or slurry, called sewage sludge, that has to undergo further treatment before being suitable for disposal or land application. Sewage treatment may also be referred to as wastewater treatment, although the latter is a broader term which can also be applied to purely industrial wastewater. For most cities, the sewer system will also carry a proportion of industrial effluent to the sewage treatment plant which has usually received pretreatment at the factories themselves to reduce the pollutant load. If the sewer system is a combined sewer then it will also carry urban runoff (stormwater) to the sewage treatment plant. There are several methods for the separation of solids and liquid in influent and effluent waters. Mechanical methods may include sedimentation, straining, flotation, and filtration. Coagulation and flocculation chemicals are used in the treatment process for water clarification, lime softening, sludge thickening, and solids dewatering and removal. In addition, we have specific chemical treatments for the wastewater needs of various industries, such as: heavy metals removal, oil/water emulsions, paint detakification, odor control, and defoaming.

Chemicals are used during wastewater treatment in an array of processes to expedite disinfection. These chemical processes, which induce chemical reactions, are called chemical unit processes, and are used alongside biological and physical cleaning processes to achieve various water standards. There are several distinct chemical unit processes, including chemical coagulation, chemical precipitation, chemical oxidation and advanced oxidation, ion exchange, and chemical neutralization and stabilization, which can be applied to wastewater during cleaning.

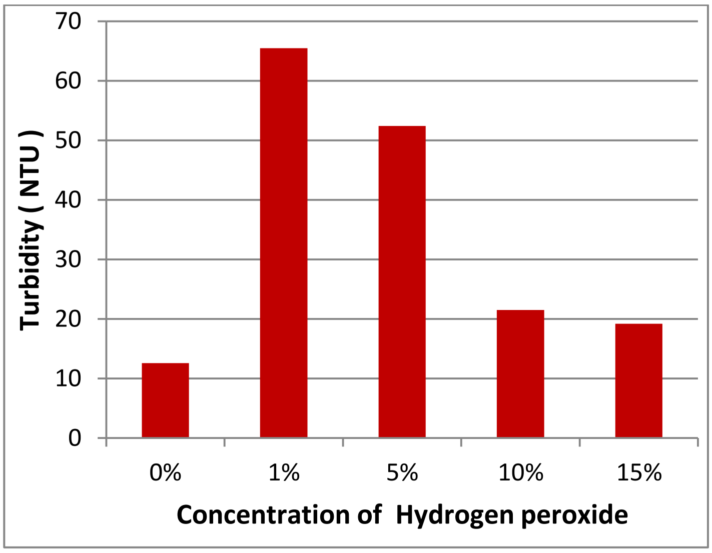
Simulated wastewater was prepared in the tank and left for a week to be fermented and ready to used.
Hydrogen peroxid and Chlorine with different concentrations.

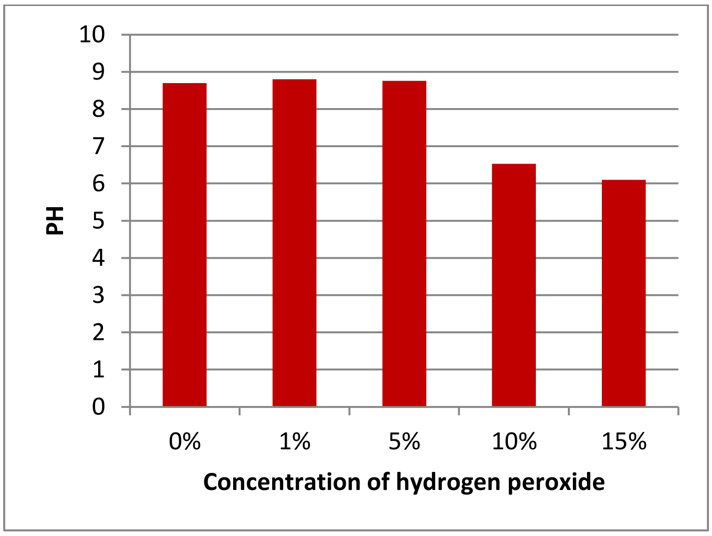
II. Methodology

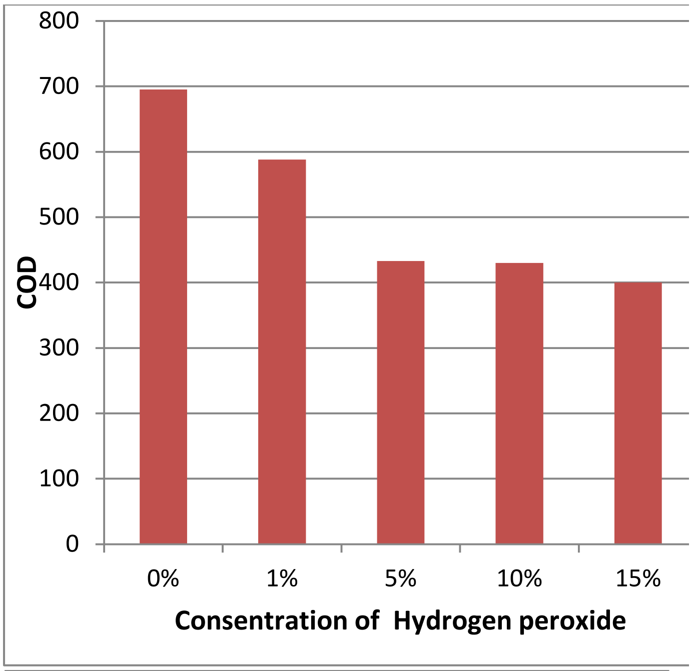
1- Simulated wastewater with reactive yellow dye was prepared .
2- Row wastewater were tested TSS, TDS, COD, Turbidity , EC and PH
3- Row wastewater was treated chemically by Hydrogen Peroxide
4- Row wastewater was treated by hydrogen peroxide and was tested by Spectrophotometer
5- The treated water was filtered by a media of activated carbon were the dye was removed.

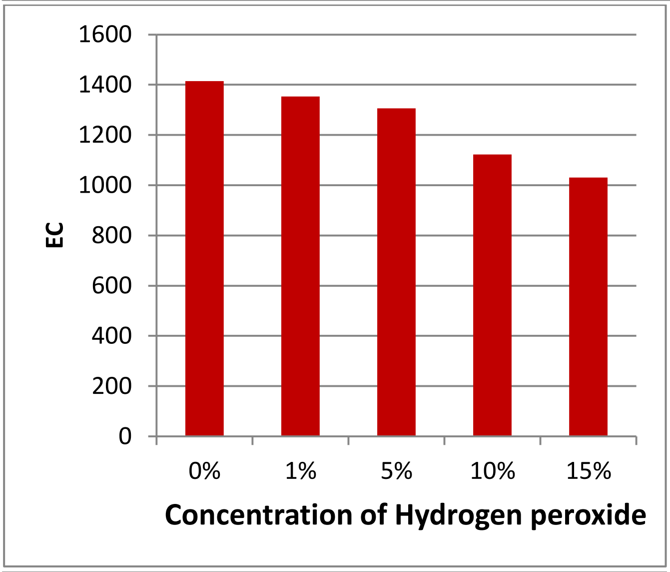
III. Results

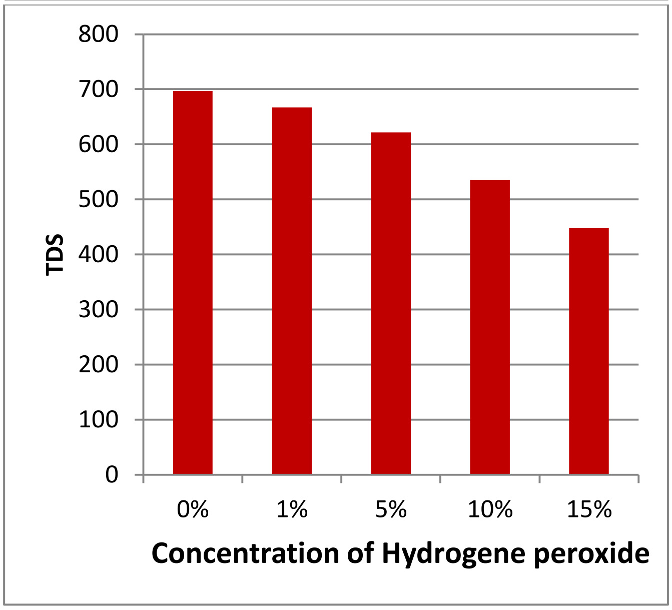
a- Wastewater treatment



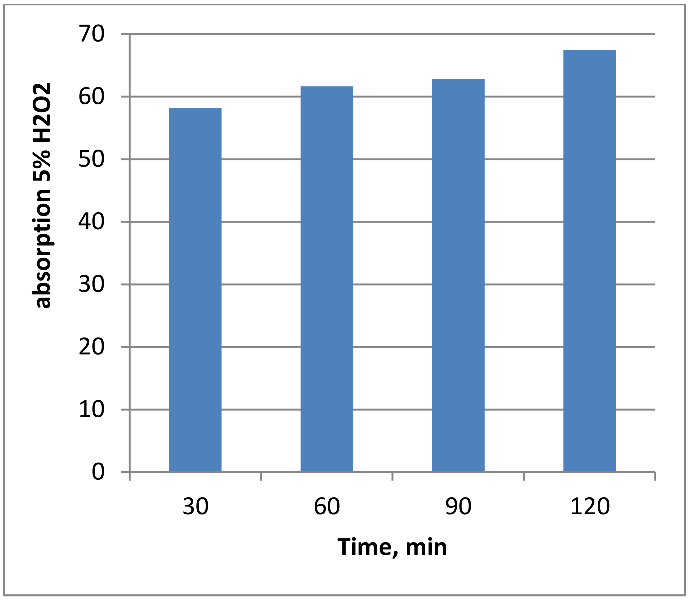




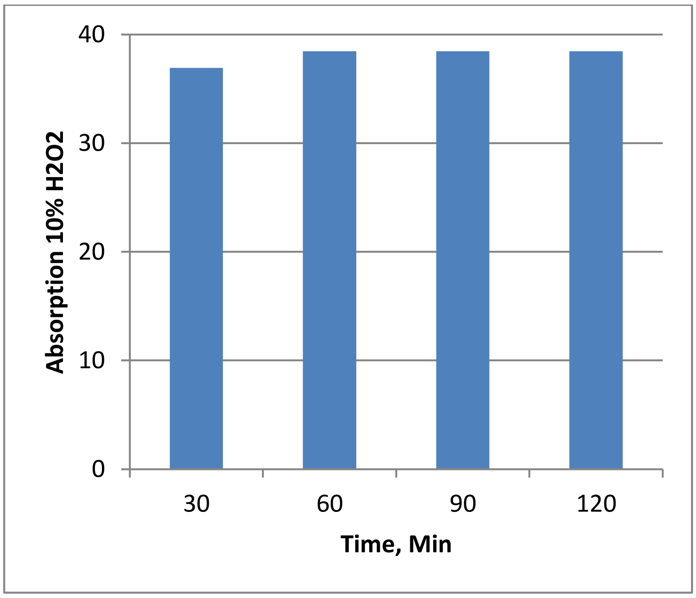




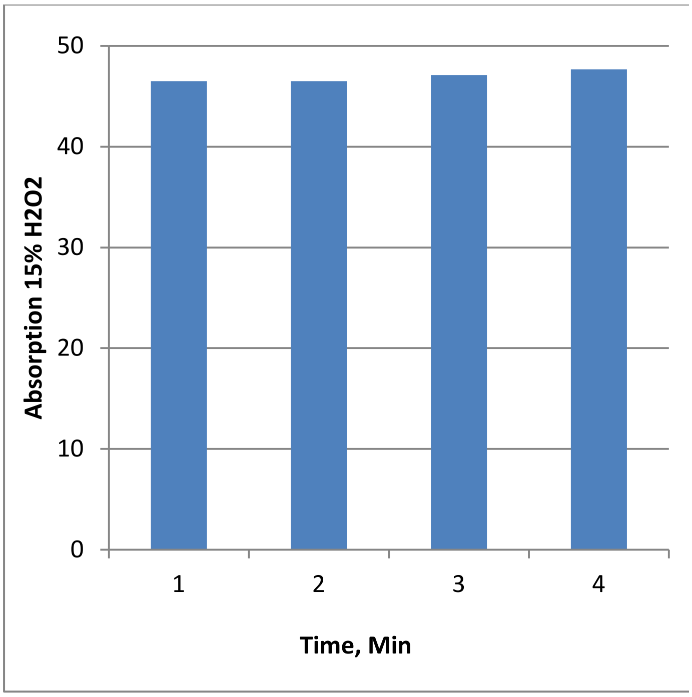
b- Dye + 5% Hydrogen peroxide



c- Dye + 10% Hydrogen peroxide



d- Dye + 15% Hydrogen peroxide



IV. Discussion

1- The treated wastewater by Hydrogen peroxide good results .
2- The removal of color was indicated slightly because of the turbidity of the origin wastewater.
3- Removal effeminacy of dye was observed by time.
4- Treatment by Peroxide was good at PH:7 temperature 20 0C.
5- Turbidity gave bad results by increasing the concentration of chlorine

V. Conclusion

6- Treated wastewater by Hydrogen peroxide gave good results .
7- Removal of dye was not indicated obviously so it is concluded that using different simultaneous techniques.
8- Activated carbon is one of the most effective adsorbants used to remove dyes from wastewater
9- This adsorbent was employed for the removal of direct dyes from spent textile dyeing wastewater.

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