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Treatment of Textile Wastewater by Electro-coagulation and Activated Sludge Process

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Environment friendly wastewater treatment method is the biggest challenge faced by textile industries. Water system around Dhaka City Corporation experiences high concentration of COD and color in the discharge effluent into environment by textile industries. Lack of appropriate treatment facility for wastewater exceeds the standard discharge limits. Conventional wastewater treatment methods become decisive challenge to environmental engineers for increasing more and more restrictive effluent by water and industrial discharges. Biologically treated discharges will no longer be reduced textiles dyes or color as 53% of 87 colors are identified as non-biodegradable. On the other hand, electro-coagulation or coagulation method produces a huge amount of hydroxide sludge that is harmful for our environment. The purpose of this study is to investigate a single treatment method that is properly and effectively treated different types of textile effluent. Electro-coagulation method for treatment of textile effluent and reduction of COD, BOD and color from effluent is compared with activated sludge process. The chemical and biological oxidation is carried out using electro-coagulation and bacillus bacteria respectively without adjustment pH of the wastewater sample. In this work, the comparison of the efficiency of electro-coagulation and activated sludge process for COD, BOD and color removal of different textile industries in Bangladesh are investigated. Electro-coagulation or coagulation method and activated sludge process results are not satisfied to protect our ecology and human health, so combined method of wastewater treatment is necessary. From cost estimation and practical performance of different treatment methods textile wastewater revealed high susceptibility to treat the effluents using electro-coagulation and biological method separately. Effluent characteristics such as color and chemical oxygen demand (COD) are reduced by considerable amount by electro-coagulation method but in activated sludge process marked degradation of pollutants than coagulation method. If we combined at first electro-coagulation then activated sludge process, a better result will be found that is more effective and economical than any single method because non-biodegradable organic matters are not destroyed by activated sludge process, so combination of methods is necessary.

Keyword: COD, BOD, pH, electro-coagulation, Activated Sludge.

1. Introduction

Textile mills are major consumers of water with an average water consumption of 160 kg per kg of finished product and consequently the most polluting industries causing intense water pollution **[1]**. Water consumption rates are very high in textiles industries than other industries and these industries causing extreme water pollution. Wastewater comprises different effluent coming from different manufacturing operation such as sizing, desizing, scouring, bleaching, dyeing, soaping and softening **[2]**. These characteristics are contingent on the specific operation performed; common characteristics are suspended solids, high temperature, unstable pH, high chemical oxygen demand (COD), high biological oxygen demand (BOD) and high colorization **[3]**. Textile effluent color is produced by laboring dyes in dyeing processes. Worldwide about 106 tons and more than 10,000 different synthetic dyes and pigments are produced annually in dyeing and printing industries [4, 5]. Other major pollutants are biocides used for processing or storage of the fiber (e.g., chlorinated aromatics), starches, solvents, fats and greases, heavy metals (e.g., chromium), salts (e.g., carbonate, sulfate, chloride), nutrients (e.g., ammonium salts, urea, phosphate based buffers), oxidizing agents (e.g., hydrogen peroxide, dichromate), reducing agents (e.g., sodium sulfide), bleaching agents (e.g., hypochlorite, hydrogen peroxide) and adsorb able organic halogens (AOX) etc. formed as a result of bleaching process [6]. Price competition, demand of high quality products, new and innovative products that are highly durable put further pressure on textile industries to use more chemicals. As a result wastewater containing higher concentrated dyes and chemicals is being discharged [7, 8]. This waste water cause extreme water pollution when encountering in natural environment. Discharged textile wastewater containing higher amount organic matter devises depletion of dissolved oxygen, which has an adverse effect on ecology. Nitrogen and phosphorous nutrients content causes an increase of biomass production in aquatic environments, this situation also creates depletion of dissolved oxygen called eutrophication [9]. Regarding high colorization, not only aesthetic pollution occurs (e.g., the eye can detect concentrations of 0.005 mg/L of reactive dye in water [10]. High color of discharged wastewater strongly inhibits absorption of the sunlight responsible for the photosynthetic activity of aquatic plants and threats for ecosystem [11]. Conventional oxidation treatments found difficulty to oxidize dyestuffs and complex structure of organic compounds even at low concentration. To simplify these problems advanced oxidation processes (AOPs), such as oxidation with Fenton's reagent have been developed that generates hydroxyl free radical to oxidize the color and COD. This process is a combined method used hydrated ferrous sulfate ($FeSO_4.7H_2O$) and hydrogen peroxide (H_2O_2) which showed great potential in textile wastewater treatment [12] but failed to treat all type textile wastewater. That's why main objective of our experiment to study the treatment of different textile wastewater to reduce chemical oxygen demands (COD) by using electro-coagulation and activated sludge process and compared these methods for wastewater treatment to reduce different critical parameters.

2. Materials and Methods

2.1 Materials

Wastewater samples are collected from different textile industries (Knit dyeing, Woven dyeing, Denim, washing plant, garments) around the Dhaka city corporation. pH meter, DO meter, Conductivity meter, Multimeter, stirred tank reactors, beakers different in size and capacity, digital type of balance, spatula, filter paper, oven, BOD incubator, COD reactor and VETROTECNICA PF-11 Spectrophotometer are used to perform this research work. Analytical grade $FeSO_4.7H_2O$, HCl, H_2SO_4, COD reagent, EDTA, and different indicator are also used for analysis.

2.2 Methods

2.2.1 Analytical Methods

The measured parameters of wastewater during the experiments are chemical oxygen demand (COD), biological oxygen demand (BOD), dissolved oxygen (DO), color (Pt-Co unit), pH, turbidity (NTU). This experiment is conducted accordingly with standard methods for water and wastewater analysis [13].

2.2.2 COD Analysis

Chemical oxygen demand (COD) measurement is carried out according to a given standard methods for the analysis of water and wastewater, titrimetric method 5220 C [13].

Chemical oxygen demand (COD) concentration is calculated using the following formula:

$$\text{COD (mg/L)} = \frac{(FAS_S - FAS_P) \times N \times f}{V}$$

Where,

FASs: used ferrous ammonium sulfate concentration for sample, mg/L

FASp: used ferrous ammonium sulfate concentration for pure water, mg/L

f: dilution factor (8000)

N: normality of FAS and

V: sample volume, ml

2.2.3 Color Measurements

A VETROTECNICA PF-11 Spectrophotometer was used for the color measurement. The measured unit is expressed at Pt-Co unit.

2.2.4 BOD determination

This method consists filling an airtight BOD bottle with sample or dilute wastewater then measured initial DO. After measured initial DO fill the airtight BOD bottle completely by overflowing the sample and sealed with Para film polymer. Incubating this sealed BOD bottle in BOD incubator at specific temperature (≤20 °C) for 5 day period. Dissolved oxygen (DO) is measured initially and after incubation, then BOD_5 is computed from the difference between initial and final DO. Because the initial DO is determined shortly after the dilution of sample but total oxygen uptakes are included in the BOD_5 measurement. Five days biological oxygen demand (BOD_5) measurement is carried out according to a standard method for analysis of water and wastewater, 5-days BOD test 5210 B [13].

2.2.5 pH Measurements

Most of the textile industry in our country dumps wastewater having a pH higher than 8. pH scale measure the acidity or basicity of a solution [14]. pH measurement is carried out by using calibrated Thermo scientific Orion Star series pH meter.

2.2.6 Dissolved oxygen (DO, mg/l)

The dissolved oxygen (DO) is oxygen that is bound by water. Dissolved oxygen is measured by a Hach sensION 6 dissolved oxygen meter, this instrument is regularly calibrated by zero calibration.

2.2.7 Turbidity (NTU)

The cloudiness or haziness properties of fluid caused by dissolved particles or suspended solids that are invisible by a naked eye, similar to smoke in air expressed as turbidity. Turbidity measurement is a key test for water quality. Turbidity of treated and untreated effluents is measured by calibrated OKATON T-100 turbidity meter.

3. Results and Discussion

3.1 Comparison of COD reduction by electro-coagulation method and activated sludge process

The efficiency of COD reduction by electro-coagulation process is comparatively lower than the activated sludge process (Biological process). Basically in electro-coagulation process metallic hydroxide is formed which settled only the color and some organics of wastewater that's why COD reduction is comparatively lower. On the other hand microorganism degrades the color and organic molecules to simple non hazardous molecules.

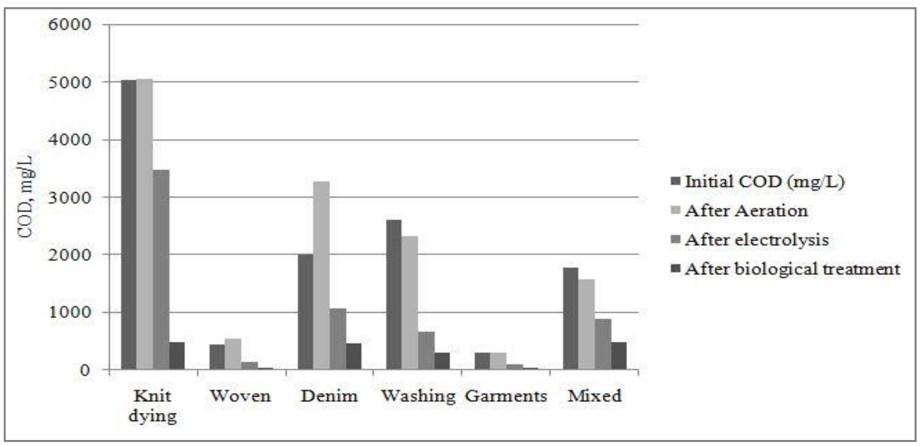

Fig 1: COD of wastewater and treated wastewater by electro-coagulation and activated sludge process

3.2 Comparison of BOD_5 by electro-coagulation and activated sludge process

Biochemical oxygen demand (BOD) measure the oxygen depletion in water which is equal to the amount of oxygen needed to survive aerobic biological organisms in water. This aerobic organism break down organic matters present in a given water sample at certain temperature over a specific time period. This test is not a precise quantitative test, although it is widely used as an indication of the organic quantity of water. The BOD value is expressed in milligrams of oxygen consumed per liter of sample during 5 days of incubation at 20 °C.

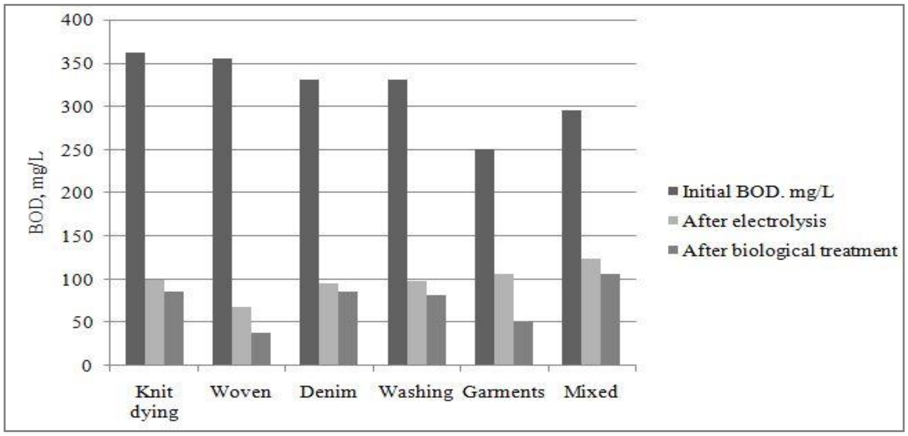

Fig 2: Compare BOD value of wastewater treated by electro-coagulation and activated sludge process

In electro-coagulation method the BOD value is decreased but not decline rate is lower than activated sludge process. High BOD value reduced the dissolved oxygen in river or lakes, as a result the fish, plant can't survive in water.

3.3 Variation of pH after electro-coagulation and activated sludge process

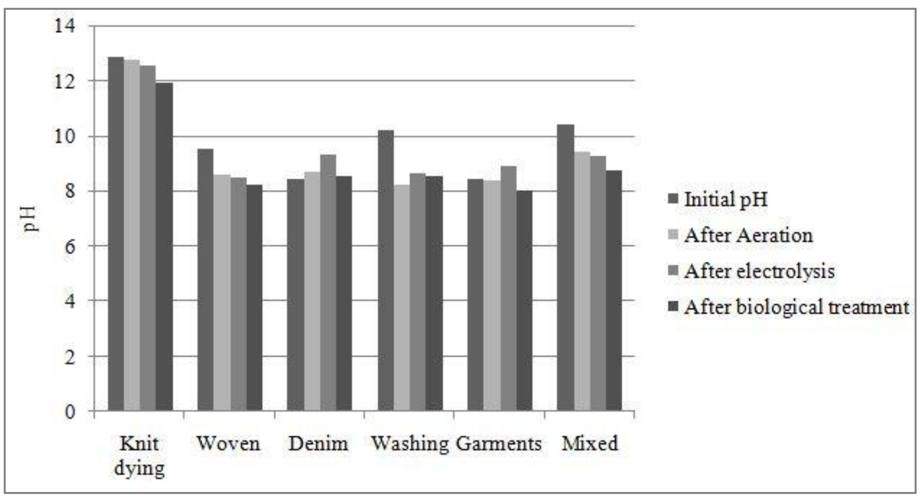

Fig 3: pH changes after electro-coagulation and activated sludge process

In this experiment during electro-coagulation the pH of the effluent partly increase due to forms hydroxide or metal hydroxide and in biological process the pH of the wastewater reduced by reacting with bacillus bacteria. Iron is used for electro-coagulation; ferrous ions are formed by electrolysis then react with hydroxide ion and coagulate as sludge but some ferrous ion still remaining in wastewater. Fe^{3+} is a common constituent of river water. Higher ferrous concentrations in acidic springs or an anoxic hyporheic zone may cause visible orange/brown staining or semi-gelatinous precipitates of dense orange ferrous bacterial flock and carpeting the river bed. Such conditions are very deleterious to most organisms and can cause serious damage in river [15].

3.4 Effect of electro-coagulation and activated sludge process on dissolved oxygen content of wastewater: In electro-coagulation process the dissolved oxygen content of treated water decreases due to formation of hydroxides and other chemical reaction but in activated sludge process, air is supplied for respiration of bacillus microorganism, as a result the dissolved oxygen is higher than electro-coagulation processes. On the other hand, photosynthesis of algae or microorganism increases the dissolved oxygen content of treated water. The above discussion is shown in the figure 4.

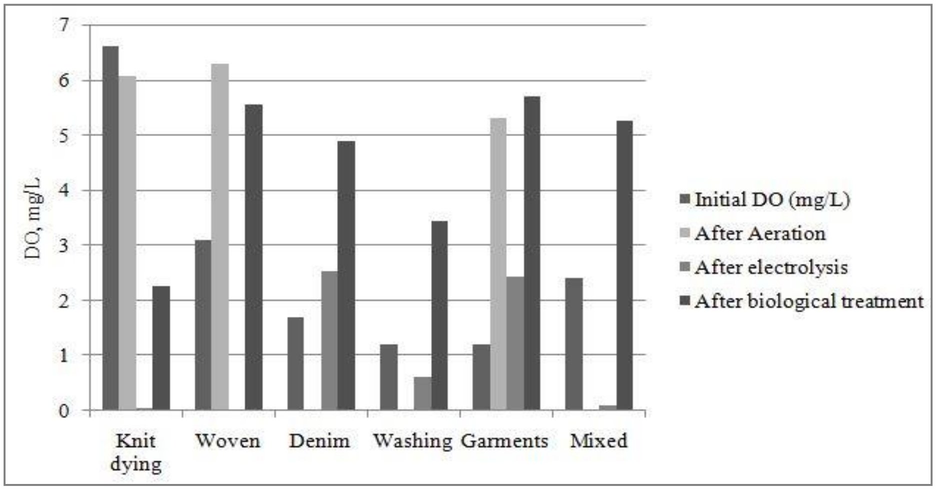

Fig 4: Effect of electro-coagulation and activated sludge process on DO content of treated textile wastewater

3.5 Turbidity measurement

The cloudiness properties of water measured in Nephelometric turbidity unit. Higher the value represents the more cloudy water. Through the cloudy medium light can't reach lower depth of river, lake and ponds. As a result submerged aquatic plants and other species which growth dependent on lights deter. So turbidity should be reduced.

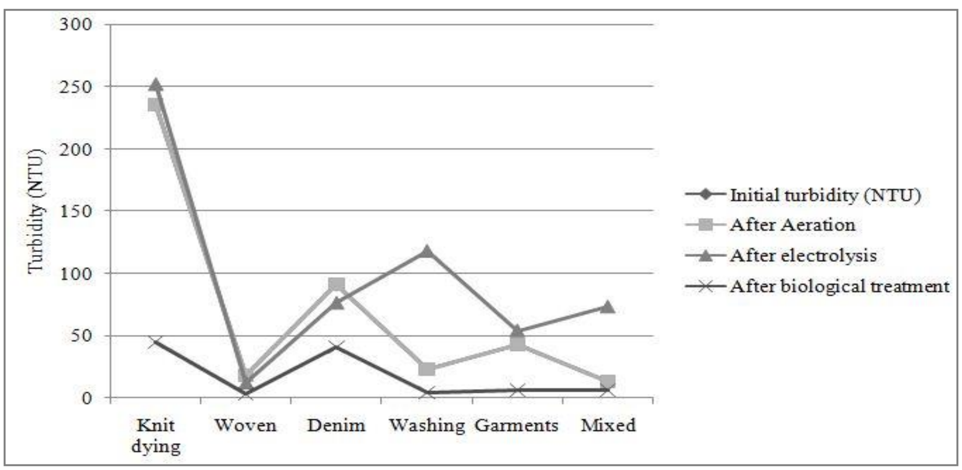

Fig 5: Effect of electro coagulation and biological process to reduce turbidity

The turbidity of treated wastewater is increased in electro-coagulation process due to formation of fine cations or hydroxides but in activated sludge process the turbidity is decreased considerably. Due to high turbidity sun light cannot reach in the depth of the river or lakes and plant lives in river cannot survive.

4. Conclusion

From the comparative study of different types of textile effluent we found that activated sludge process is more suitable for all types of effluent treatment than electro-coagulation or other chemical methods. COD and BOD, is one of the critical parameters for discharge into environment, in activated sludge processes this value degrading rapidly than electro-coagulation method. DO value decrease in electro-coagulation/other chemical method but in activate sludge process this value remains constant and pH value partially degrade but almost unchanged that's why pH adjustment is needed for effluent treatment in both methods. In our experiment it is conclude that activated sludge process is more efficient, environment friendly and cheap than other methods.

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