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Electrochemical treatment method in paper recycling industry effluent

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Abstract

This industries in terms of water and, accordingly wastewater production considered as pollutant effluent due to having various kinds of organic and mineral materials. Therefore, in order to pump it to environment or reuse it, electro coagulation method was used to remove various compounds from effluent produced in paper recycling industry. The objective of this paper is to study the possibility of produced effluent treatment in paper recycling industry using electro coagulation in order to reach necessary standards and easy implementation of wastewater treatment procedures. At first, raw effluent was analyzed after a sedimentation phase in which solid suspended substances such as fibers were separated from liquid phase. Then they were transferred to electro coagulation phase and removal efficiency of measured parameters such as COD, BOD, TSS, TDS, Conductivity, Turbidity levels were studied in electric potential range of 6-12 volt during 10, 20, and 30 minutes in three different pH (pH=7, 5.5 ,8.5). The results showed that increased electric potential and reaction time rise electro coagulation efficiency in that the maximum The maximum contaminant removal efficiency measures of pollutant indicators happened at potential difference of 12 volt, reaction time of 30 minutes, and pH=8.5 for COD, BOD, TSS, Turbidity, TDS and Conductivity which are reported 51.04%, 51.8%, 95.6%, 83.7%, 1.34%, and 2.69%, respectively. It is inferred that electro coagulation process enjoys appropriate efficiency to remove pollutants in paper mill effluent industry.

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Introduction

Nowadays, we are experiencing high consumption of water resources due to technological advances and growing industries. Among industries, although using and collecting scrap paper recycling help environment, high volume of water resources and various chemicals are needed because of production procedures and in particular in deinking unit. Pulp production and paper recycling industries, as cellulose industries, are some of highly-consumed industries concerning water consumption and accordingly, they are considered as biggest producers of industrial effluent.

Effluent of such industries has unpleasant effectiveness such as increased color, odor, and oxygen demand in acceptant water due to late decomposition and complex organic materials such as cellulose and Lignin. It severely endangers aquatic life and it leaves negative effects like mutation and release of carcinogens. (Hemmatabadi and Rabi, 2012; Bazrafshan *et al.*, 2012; Ali and Sreekrishnan, 2001; Ugurlua *et al.*, 2008). Effluent production resources are different in this industry depending on geographical location, type of collected and consumed paper as well as internal scrap paper processing system. The source of these pollutants can be chemical additives used in the paper machines such as fillers, sizing types, colors, conversion additives such as printing ink additives, pigments, adhesives, and chemical additives to flatten paper and cardboard, and extensive range of materials and impurities added to the paper by consumers.To reduce effluent of these industries, a wide range of treatment procedures are used: physical, chemical, biological and aerobic (Hemmatabadi and Rabi, 2012; Ragunathan and Swaminathan, 2001) treatment procedures; ozone treatment; and the process of mixing treatments (Hemmatabadi and Rabi, 2012; Pokhrel and Viraraghavan, 2004) Each of these methods has some advantages and disadvantages. Like for instance, biological method is not appropriate for effluent treatment of pulp and paper mills because high weight organic materials such as lignin annular compounds cannot be easily treated by ordinary microorganisms in effluent. (Hemmatabadi and Rabi, 2012); Khansorthong and Hunsom, 2009). Also, although biological procedures are influential and cost effective in some cases, the utility of this method is somewhat reduced due to long hydraulic retention, high volume of reactor, and high concentration of biomass output (Bazrafshan *et al.*, 2012). Expensive chemical materials are reported as the main drawback of this method for effluent treatment. Also, pumping chemical materials to nature is incompatible with environment. Generally, the main disadvantage of these methods is expensive implementation and low efficiency to reduce effluent (Hemmatabadi and Rabi, 2012; Cecen *et al.*, 1992; Ugurlua *et al.*, 2008).

Electro coagulation is basically an electrolysis reaction where electro chemical reaction requires applying appropriate electric potentials between two or more metal or aluminum electrodes in order to do reaction in shared level of electrode and solution through one external electric source. In this process, pollutant removal agent (iron or aluminum hydroxide clot) is produced through applying electric current to floating electrodes plate in treated sample during oxidation and reduction reactions (Jafar Zadeh and Daneshvar, 2006; Parga *et al.*, 2005). In electrocoagulation process, coagulant is produced in place through electrolytic oxidation of a suitablematerial anode. In other words, this process leads to production of metal cations through electrochemical from using consumable anodes (usually iron or aluminum). Cation hydrolysis in water causes the formation of an aluminum hydroxide $Al(OH)_3$ with the proportionally pH dominant species of the solution. Then pollutants such as organic compounds in environment are removed according to some mechanisms likeparticles trapping in the sediment, sweeping coagulation, sedimentation, flotation and adsorption. (Bayramoglu *et al.*, 2006); Bazrafshan *et al.*, 2012; Nouri *et al.*, 2010). Electrocoagulation is considered as one of the most effective methods to treat water and effluent

because of enjoying somecharacters like extensive range of treating action for different types of industrial effluents, simple designing of system, low implementation and application costs, no need for certain chemicals, low production of additional sludge (Yousuf *et al.*, 2001; Jafar Zadeh and, Daneshvar 2006; Daneshvar *et al.*, 2001). Environmental compatibility, high energy productivity, safety, and automatic and optimum efficiency concerning cost are some advantages of this method. (Bayramoglu *et al.*, 2006; Nouri *et al.*, 2010; Bazrafshan *et al.*, 2012; Asselin *et al.*, 2008). This paper studies the efficiency of electrocoagulation in treating effluent of paper recycling industry. The objective of this paper is to study the possibility of treating effluent from paper recycling through electrocoagulation process in order to reach the standard range of permissible discharge of pollutants for industrial effluent in Iran as well as to study the effect of operating variables such as electric potentials, reaction time, and effluent pH on pollutant removal efficiency.

Material and methods

Sampling

Sampling was done from paper recycling mill effluent treatment system using different types of scrap paper used to produce rolls of paper napkins. Input effluent to effluent treatment system of this mill includes a considerable number of suspended solid particles and fibers. Quick sedimentation is the main reason to set up a sedimentation unit at the entrance of effluent to effluent treatment system where, after integration, suspended fibers and solids are separated in a short time. Thus, a large portion of suspended COD is removed from effluent. To do other stages of effluent treatment, it is necessary that this effluent be sent to other chemical and biological treatment units. To this end, an important portion of COD level and other pollutants should decline to increase the efficiency of other effluent treatment units especially while treating biological treatment process. That is why using electrochemical treatment processes is tested in this stage (effluent which passed on stage of sedimentation).

Procedure

First, compound sampling was done for 50 liters. Then samples were transferred to laboratory for analysis and they were kept at 4°C. All tests were conducted in lab temperature inside a 500 ml glass reactor. To conduct the test, 5*10 iron electrodes were placed with 2cm gap from each other and they were connected to two poles of power supply by linking wires. Electric energy supply was an electric converter where the input is power flow of 220 volt and the output is 6 and 12 volt. While conducting tests, electrodes were placed inside tested sample and were poured in decanter funnel after applying desired voltage and test duration. After forming clot sedimentation, mentioned effluent is used for next tests in order to evaluate COD, BOD, Turbidity, TSS (Gravimeter), and TDS reduction.

All tests were repeated three times and parameters including COD and BOD levels were measured according to water and wastewater standard (APHA, 1995). TDS, pH, and conductivity levels were measured by METTLER TOLEDO multi parameter device. Turbidity level was measured by DR2800 HACHLANGE Spectrophotometer.

Since an oxide layer is formed on anode surface during electrocoagulation, electrodes were washed after each time of test with 5% choloridric acid dilute solutionand were accurately weighed after washing with distilled water. Determining initial and final electrode weights is done to calculate consumed electrode.

Analysis Method

Power consumption was calculated during electrocoagulation process through recording current intensity as well as voltage according to experimental equations.

Result and discussion

Biological procedures are influential and cost effective in some cases, the utility of this method is somewhat reduced due to long hydraulic retention, high volume

of reactor, and high concentration of biomass output . Expensive chemical materials are reported as the main drawback of this method for effluent treatment. Also, pumping chemical materials to nature is incompatible with environment. Generally, the main disadvantage of these methods is expensive implementation and low efficiency to reduce effluent.

Electro chemical reaction

Electro coagulation is basically an electrolysis reaction where electro chemical reaction requires applying appropriate electric potentials between two or more metal or aluminum electrodes in order to do reaction in shared level of electrode and solution through one external electric source. In other words, this process leads to production of metal cations through electrochemical from using consumable anodes (usually iron or aluminum). Pollutants such as organic compounds in environment are removed according to some mechanisms like particles trapping in the sediment, sweeping coagulation, sedimentation, flotation and adsorption. Electrocoagulation is considered as one of the most effective methods to treat water and effluent because of enjoying some characters like extensive range of treating action for different types of industrial effluents, simple designing of system, low implementation and application costs, no need for certain chemicals, low production of additional .Environmental compatibility, high energy productivity, safety, and automatic and optimum efficiency concerning cost are some advantages of this method.

PH and imposed voltage affected

The results indicate the fact that the efficiency of paper-making sewage pollutant removal is affected by various factors such as pH and imposed voltage so that rise in each of these mentioned factors leads to treatment efficiency rise. Removal efficiency will noticeably rise by imposed voltage rise for a certain reaction duration. The basis is that more deposits and clots will form in higher voltage in order to eliminate pollutants (Fig 1-3).

The results showed that increased electric potential and reaction time rise electro coagulation efficiency in that the maximum The maximum contaminant removal efficiency measures of pollutant indicators happened at potential difference of 12 volt, reaction time of 30 minutes, and pH=8.5 for COD, BOD, TSS, Turbidity, TDS and Conductivity which are reported 51.04%, 51.8%, 95.6%, 83.7%, 1.34%, and 2.69%, respectively (Table 1). It is inferred that electro coagulation process enjoys appropriate efficiency to remove pollutants in paper mill effluent industry (Fig 4-5).

Asselin *et al.*, (2008) in their research entitled "electrochemical process in slaughterhouse wastewater using mono-polar and bipolar electric cells" realized that COD removal level rises noticeably by increased contact time from 0-90th minute with 2 Amper current in iron and aluminum electrodes (Fig 6). Also, results of studies in 2009 show that increased consumption voltage pollutant removal rate declines. Similar researches reached the same results, meaning that increased duration leads to COD removal level rise. Electrocoagulation process is one of effective methods to treat effluent of paper recycling industry which is run by simple equipment. It has less exploitation cost due to no need to chemical materials. This process is an appropriate method to treat such effluent through applying iron electrodes.

Table 1. Raw effluent properties before conducting electrochemical treatment.

Measured parameters	pH	TSS (mg/l)	TDS (mg/l)	BOD (mg/l)	COD (mg/l)	Turbidity (FTU)	Conductivity (ms/cm)
Raw waste water (before treatment)	7	115	1333	826	2108	124	2.6

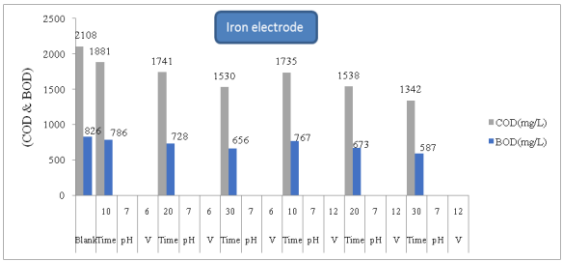

Fig. 1. COD and BOD trend of change in pH= 7 using electrochemical method.

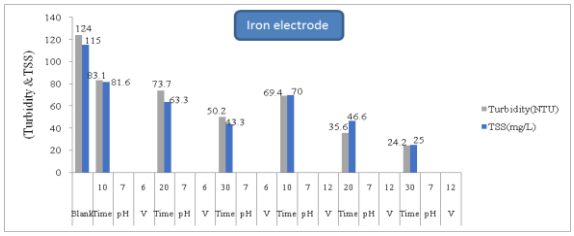

Fig. 2. Turbidity and TSS trend of change in pH=7 using electrochemical method.

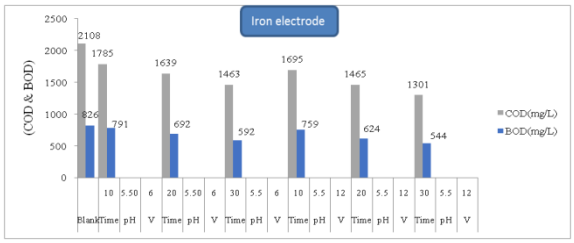

Fig. 3. COD and BOD trend of change in acidic pH using electrochemical method.

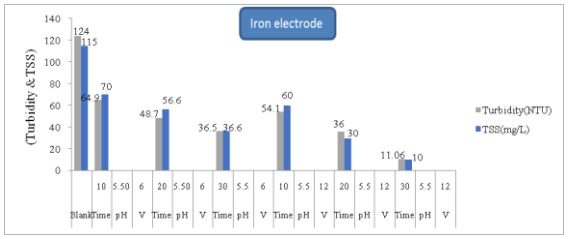

Fig. 4. Turbidity and TSS trend of change in acidic pH using electrochemical method.

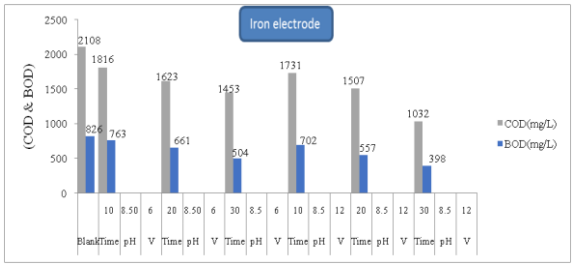

Fig. 5. COD and BOD trend of change in alkaline pH using electrochemical method.

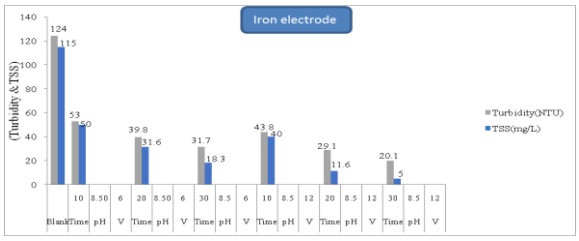

Fig. 6. Turbidity and TSS trend of change in alkaline pH using electrochemical method.

Conclusion

Results of electrochemical process show that increased voltage leads to reduced power consumption and reaction time of waste water pollutant removal efficiency resulted from paper making process. Following conclusions are drawn from this study: COD level in the best efficiency is reported in alkaline pH of 8.5, reaching from 2108 to 1032 mg/l with efficiency of 51.01%; BOD level in the best efficiency declined from 826 mg/l to 398 mg/l with efficiency of 51.8%; Turbidity level reached from 121 (NTU) to 20.1 (NTU) with efficiency of 83.8%; and TSS level declined from 115mg/l to 5mg/l with efficiency of 95.9%. Also, increased reaction duration from 10 to 30 minutes caused COD to reduce steadily in that duration time of 30 minutes shows the highest pollutant indicator removal. It is noteworthy that power and electrode consumption rises at time of 30 minutes and voltage of 12 volt. This rising pattern is seen more in acidic pH rather than neutral and alkaline environments. Asselin *et al.*, (2008) in their research entitled "electrochemical process in slaughterhouse wastewater using mono-polar and bipolar electric cells" realized that COD removal level rises noticeably by increased contact time from 0-90th minute with 2Amper current in iron and aluminum electrodes.

Recommendations

It is recommended to use of aluminum electrode instead iron electrodes. Also by increasing the voltage, efficiency of this type of treatment will be improve.

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