TREATMENT OF BUTCHER'S SHOP WASTEWATER BY ELECTRO-COAGULATION USING ALUMINUM AND IRON ELECTRODES

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ABSTRACT

Wastewater contains various and high amounts of organic matter. Untreated butcher shops wastewater entering into a municipal sewage purification system may create severe problems, due to high biochemical oxygen demand (BOD) and chemical oxygen demand (COD).This study aims to investigate the feasibility of treating butcher shop wastewater by electro-coagulation process which is known as a technique for removing organic content from wastewater to produce an effluent suitable for stream discharge. In this context, a laboratory scale electro-coagulation treatment system was developed to observe its performance in treating the wastewater from butcher's shop in batch operation. The consequence of various process variables such electrode material, initial pH, applied voltage, and operating time was investigated. The electrolytic cell (electro-coagulator) used in this study was made of a 500 ml cylinder glass reactor with working volume 250 ml. Iron (Fe) and aluminum (Al) sheet with effective area of 24 cm^2 were used as cathode and anode, respectively. The influence of the operating variables such as electrical potential (voltage) and reaction time on the removal efficiencies of major pollutants were determined. The rate of removal efficiency was found to be linearly increased with applied voltage as well as operating time. BOD and COD removal efficiency was achieved more than 80% with applying 24V voltage for an operating time of 30 min.

Keywords: *BOD, butcher shops wastewater, COD, electro-coagulation*

1. INTRODUCTION

Ever increasing industrialization and rapid urbanization have considerably increased the rate of water pollution. The dwindling supplies of natural resources of water have made this a serious constraint for industrial growth and for a reasonable standard of urban living. The environmental protection agencies have imposed more strict regulatory prohibitions to shield the environment. This has made the water treatment more expensive and to fulfill with the discharge quality standard itself, is becoming a huge burden for the industries. The pollution of water resources due to discharge of poor quality effluents poses a serious threat to human beings and aquatic organisms since they rely on water for sustenance. The problem is more rigorous in developing countries where rapid population growth and industrialization has increased complexity of effluents (Elhassadi, 2008). In recent years, researchers have shifted their interests in potential reuse and recycling of various effluents where food industries are no exceptions to it (Balannec *et al.,* 2005). In most cases, these effluents are not treated and are simply thrown into rivers. The food processing industries including diary, sweet-snacks, ice-cream, and butcher's shop consume large quantities of water. The effluents of these industries in general are characterized by Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) along with many other recoverable nutrients like Nitrogen, Phosphorous, and Potassium. Untreated effluents of Butcher's shop entering into a municipal sewage system may create severe problem due to the very biochemical oxygen demand (BOD) and chemical oxygen demand (COD). The treatments of butcher's shop wastewater by various methods such as aerobic and anaerobic systems (Torkian *et al.,* 2003; Manjunath *et al.,* 2000) have been intensively studied. Aerobic treatment processes are limited by their lofty energy consumption required for aeration and high sludge production. In addition, it is also reported that anaerobic treatment is susceptible to high organic loading rates, as a serious disadvantage (Cuetos *et al.,* 2008). Even though biological processes are effective and economical, both biological processes require long hydraulic retention time and large reactor volumes, high biomass concentration and scheming of sludge loss, to avoid the wash-out of the sludge.

Recently, electrochemical methods such as electro-oxidation (Tezcan *et al.,* 2008) and electro-coagulation have been widely used as an eye-catching and suitable method for the treatment of various kinds of wastewater such as poultry and cattle slaughterhouse wastewater and wastewaters contain heavy metals, by virtue of various

benefits including environmental compatibility, flexibility, energy efficiency, safety, selectivity, amenability to automation, and cost effectiveness (Bayramoglu *et al.,* 2006; Bazrafshan *et al.,* 2012)
With the up-to-the-minute technologies, reduction of electricity requirements, and miniaturization of the needed power supplies, Electro-coagulation (EC) systems have now become affordable for water treatment plants and industrial processes worldwide. Electro-coagulation was found particularly useful in wastewater treatment (matveevich, 2000). It has been employed in treating wastewaters from textile, catering, petroleum, tar sand and oil shale wastewater, carpet wastewater and municipal sewage.

Presently the Butcher shops in Bangladesh are being used in such a way that the wastes come from these are polluting the surrounding environment such as river water, solid surface, air etc. The research finding reveals that the total quantity of waste produced from these slaughter houses was 2888.45 tons/year (Amin, 2009).
This study aims to develop a laboratory scale electro-coagulation batch reactor for treating the wastewater from butcher's shop. The second objective is to determine the removal efficiency of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) from wastewater using electro-coagulation process. To determine the optimal condition for maximum removal efficiency of organic matters is the third and final objective of this study.

2. METHODOLOGY

2.1 Study area

Fulbari-Gate bazaar was selected as study area which is situated at Khan jahan ali thana of Khulna district in Khulna division, Bangladesh. The coordinate of the study area is $22^{0}53'46''$N and $89^{0}30'37''$E. Five butcher shops of Fulbari-gate bazaar were selected as collection point .Wastewater was collected from the selected Butcher shops for lab tests and treatment performances.

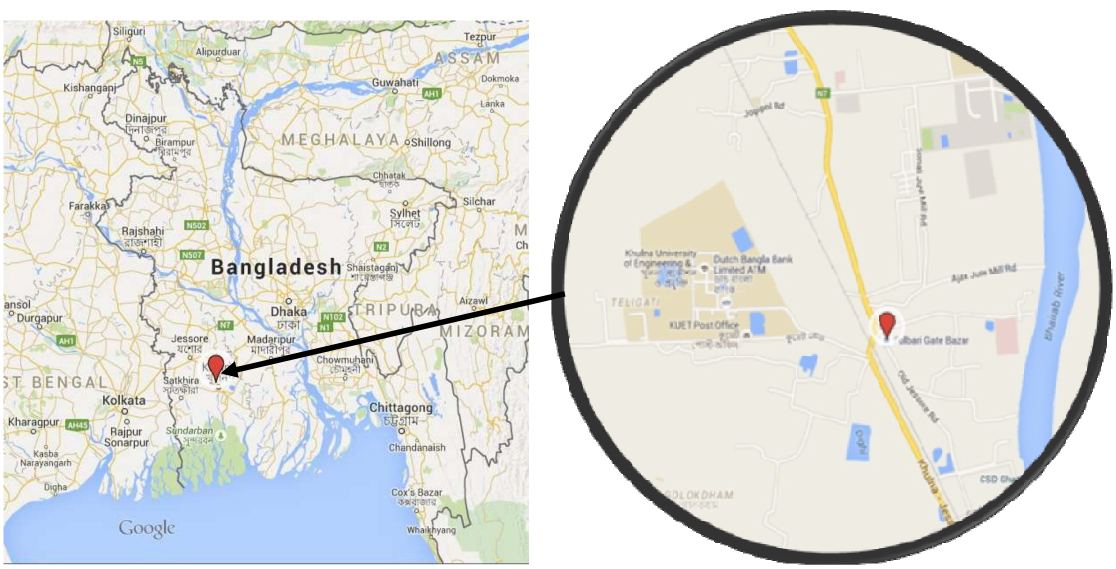

Figure 1: Location of study area (google map)

2.2 Effluent materials

The wastewater samples were obtained from slaughterhouses/butcher shops at fullbarigate bazaar. Five sample of wastewater in five consecutive months were collected in standard procedure (APHA, 2005).

2.3 Design and Development of Electro-coagulation Unit

A typical electro-coagulation cell consists of DC power supply, anode, cathode, electrolytic cell, magnetic stirrer. The anode and cathode electrode may vary from iron-iron, iron-aluminium, and aluminium-aluminium. The equipment uses to construct the electro-coagulation (EC) unit are mentioned in below.
Dc transformer: A 220v to 12V/24V step down DC transformer was used to regulate the voltage.

Anode and Cathode: An aluminium sheet of 100 mm X 10 mm was used as anode and an iron sheet of same size (100 mm X 10 mm) was used as cathode. The aluminium anode was connected to the positive end and the iron cathode was connected to the negative end of the output of DC transformer.

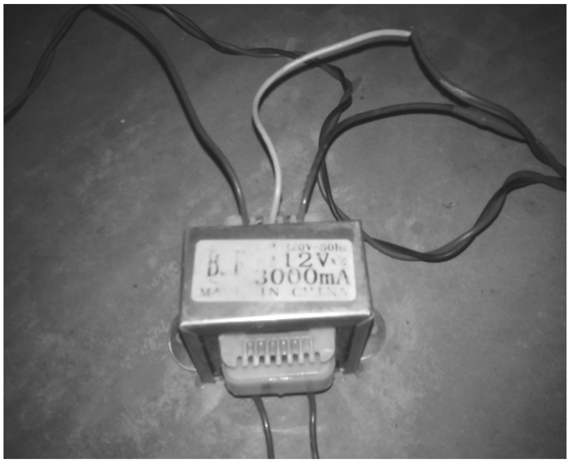

Figure 1 : Photographic view of equipment used for EC unit

3. RESULTS AND DISCUSSION

Three different samples of waste water were used for initial Chemical Oxygen Demand (COD) & Biochemical Oxygen Demand (BOD) tests and also after electro-coagulation the same tests were performed for treated waste water. In addition the treatment procedure was varied by voltage and time. From the test results the efficiency was determined.

Table 1: Initial and Final BOD values along with efficiency

sample	Voltage= 12V			Voltage= 24 V			time
	I	F	E (%)	I	F	E (%)	
1	289.56	228.04	26.98	289.56	191	51.60	
2	319.65	249.38	28.18	319.65	216.23	47.83	10
3	128.14	97.62	31.26	128.14	81.42	57.38	
1	289.56	183.88	57.47	289.56	164.15	76.40	
2	319.65	230.71	38.55	319.65	189.45	68.63	20
3	128.14	85.75	49.43	128.14	70.67	81.32	
1	289.56	159.13	81.96	289.56	151.07	91.67	
2	319.65	191.18	67.20	319.65	174.29	83.40	30
3	128.14	72.38	77.04	128.14	67.11	90.94	

From the table it is obvious that the concentration of BOD_5 is decreasing with the passage of operating time. It's also notable the voltage increase has a great impact in changing concentration of BOD_5. Highest BOD5 removal efficiency was found around 82% for 12V and 90% for 24V.

Table 2 : Initial and Final COD values along with efficiency

sample	Voltage= 12V			Voltage= 24 V			time
	I	F	E (%)	I	F	E (%)	
1	640	544	17.65	640	480	33.33	
2	736	608	21.05	736	544	35.29	10
3	512	416	23.08	512	352	45.45	
1	640	512	25.00	640	384	66.67	
2	736	576	27.78	736	448	64.29	20
3	512	384	33.33	512	320	60.00	
1	640	416	53.85	640	352	81.82	
2	736	512	43.75	736	416	76.92	30
3	512	352	45.45	512	288	77.78	

From the table 2 it is observe that also the concentration of COD is decreasing with the increment of operating time. The voltage increasing has also made a great impact in changing concentration of COD.
Correlation between removal efficiency and operating parameters (Voltage and time) are illustrated in figure 1 and figure 2.

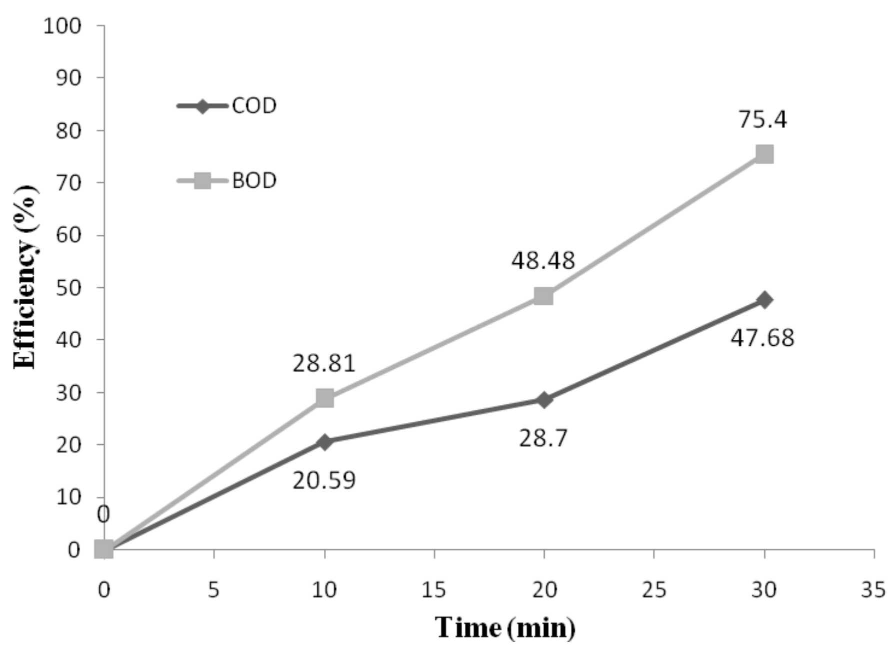

Figure 1: COD and BOD efficiency with time and optimal voltage of 12V

Figure 1 shows that the trend line for BOD removal efficiency was more linear than the COD removal efficiency. The removal efficiency was directly related to the concentration of ions generated on the electrodes. Increasing the operation time had a major role in the performance of the electro-coagulation process. The ions concentration increased with the time of electrolysis. As a result, the maximum efficiency was found 75.4% &

47.7% at operating time of 30 min for BOD & COD, respectively. In case of BOD the efficiency was around 29%, 49% & 75% when the time was 10 min, 20 min and 30 min, respectively. This indicates that removal efficiency increase 2.5 times while the time increases 3 times. This happened because the operation time incrassation had a great influence over ions concentration increase. More the ions concentration increases much the removal efficiency increase because ions concentration acts as in situ coagulants which are responsible for reducing biochemical oxygen demand. The same theory goes for COD but this time the removal efficiency increase 2.2 times while the time increases 3 times.

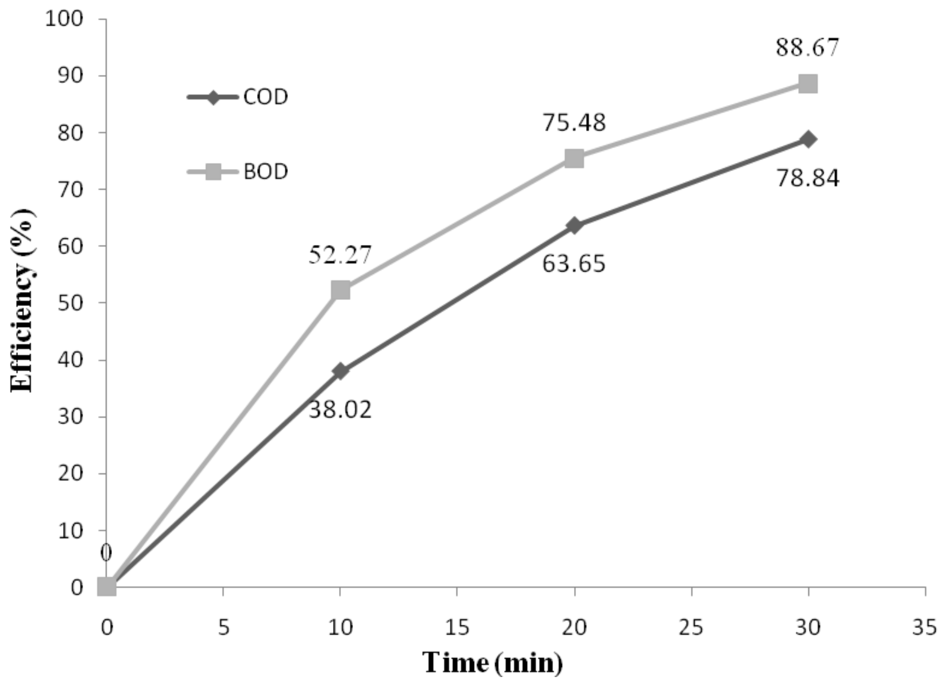

Figure 2: COD and BOD efficiency with time and optimal voltage of 24V

When the applied voltage is 24 V the maximum efficiency was found 88.7% & 78.8% (Figure 2) for BOD & COD, respectively. In that case the trend line is less linear for both BOD & COD removal efficiency. BOD removal efficiency increases as shown in previous with the incrassation of time. For COD removal the same thing also happens. One of the most important parameters that can affect the electrochemical process is the applied voltage. As the applied voltage increased, the removal efficiency and the current passing through the solution increased. The latter caused dissolution of aluminum from the sacrificial electrode forming aluminum hydroxide species. These species neutralized the electrostatic charges on dispersed particles to reduce the electrostatic inter-particle repulsion. As a result at 30 min operating time the BOD removal efficiency was 75% and 89% for 12V and 24V, respectively. And for COD the efficiency was 48% and 79% for 12V and 24 V, respectively.

4. CONCLUSIONS

The first objective was to develop a laboratory scale electro-coagulation batch reactor for treating the wastewaters from butcher's shop which was accomplished by developing an electro-coagulation cell unit containing a DC transformer, an Aluminum anode and Iron cathode of effective area 24 cm^2, respectively. Concerning the second objective, the removal efficiency for both BOD and COD of waste water was determined. Increasing the operation time had a major role in the performance of the electro-coagulation process. As a result the removal efficiency of BOD was found around 29%, 48% and 75% when the operating time was 10minutes, 20 minutes & 30 minutes, respectively and the applied voltage was set 12V all the time. In case of COD, removal efficiency was found 21%, 28% and 48% for operating time of 10minutes, 20 minutes & 30 minutes, respectively. Also the results demonstrated that increasing the voltage at a constant electrolysis time, the removal efficiency was increased. For that reason the BOD removal efficiency was found around 75% & 89% when applied voltage was 12V & 24V, respectively though the operating time was 30 minutes for both. In the event of COD removal when the operating time was 30 minutes the removal efficiency was found 48% and 79% for applied voltage of 12V and 24V, respectively. Hence the optimal condition was found 24V with 30 min operating time of electro-coagulation. This completes the task of third objectives to find the optimal circumstance.

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