TREATMENT OF SHOBRA EL-KHEIMA POWER PLANT LIQUID WASTE USING ELECTROCHEMICAL COAGULATION

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ABSTRACT

The aim of the present work was to evaluate the removal efficiency of several contaminants from power plant wastewater. It included biochemical oxygen demand (BOD), chemical oxygen demand (COD), turbidity, total iron, total dissolved solids (TDS) and total suspended solids (TSS) and others by using electrochemical coagulation technique. Samples were collected from power station wastewater by electrochemical treatment (EC) using laboratory scale electrochemical cell to remove some of contaminants. Results obtained showed that the optimum conditions were pH = 8, 12 volts and 0.8 amp. The maximum removal of contaminants such as (TSS) was 94.6 % at 10 minutes, while for BOD it reached 54.2% at 14 minutes. The percentage removal of COD reached 72.3% at 12 minutes. In regard to total iron, the maximum removal reached 88.6 % at 16 minutes.

Key words: Electrochemical coagulation, wastewater, Liquid waste, Power plants, Aluminium electrode.

INTRODUCTION

The conventional techniques for treating water may occasionally become time-consuming, costly, and leaves some solid waste (sludge), and technical expertise may be necessary (Crites *et al.,* 2014). Additionally, some of the solutions might not be commercially feasible in some businesses (Kim *et al.,* 2013). Therefore, raw and industrial wastewater may be treated by electrocoagulation. For a variety of reasons, electrocoagulation-flotation is an alternative to traditional chemical coagulation. According to the amount of water being treated, traditional chemical coagulation methods include alum (aluminum sulfate), ferric chloride ($FeCl_3$), or ferrous sulfate (Fe_2SO_4), all of which can be quite costly. At room temperature and pressure, the electrocoagulation process only requires very basic equipment and operates on the oxidative or reductive chemistry principle. According to previous publication, electrocoagulation requires little space, produces little

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sludge, and requires little time for treatment (Chaturvedi 2013; Inan and Alaydin, 2014). Various important components may be extracted from the sludge and water effluent created by electrocoagulation and utilized as fertilizer (Bridle and Skrypski-Mantele, 2000; Sethu *et al.,* 2008; Gaber *et al*., 2011; Sano *et al*., 2012). The electrocoagulation's effluent output can be used for industrial, agricultural, and drinking applications (Yi *Mao et al*., 2023; Fathy *et al.,* 2020; Ingelsson *et al.,* 2020).

Many industries have a lot of wastewater which need treatment before reuse. These effluents must be treated for environmentally friendly discharge (El-Kareish *et al.,* 2018). For economic benefit, the cost of treatment should be kept as low as possible. However, most conventional treatment techniques are expensive. Therefore, non-traditional technologies must be applied to reduce treatment costs, reuse or recycle process effluents and minimize the amount of sludge resulting from these processes. Limited studies have been found in literature concerning electrocoagulation especially in power station waste water (Fathy *et al.,* 2020). Accordingly, the aim of this work was conducted to use electrocoagulation technique for the treatment of industrial wastewater from power plant.

MATERIALS AND METHODS

Electrochemical cell:

Electric DC power source (M&R1502 TD) with output volts (0-15V) and current (0-2 ampere) was used as the source of direct electric current applied during electrochemical treatment of wastewater.

Aluminum electrodes (plates) were used as working electrodes into the electrolytic cell and connected to the positive terminal and negative one of the DC Power. The electrochemical unit and cell plates were illustrated in Figures 1&2. Data presented in Table1. showed the determined parameters of raw wastewater.

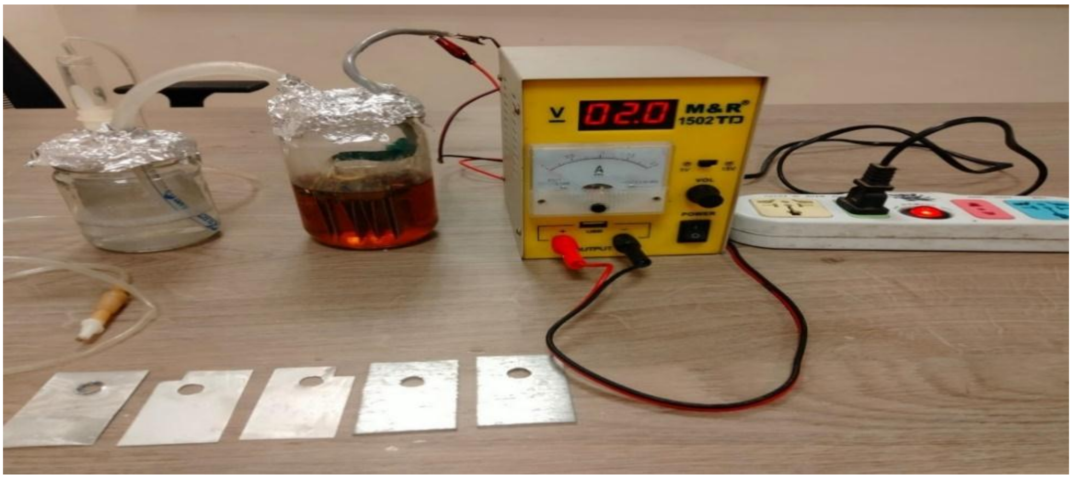

Figure 1. Lab scale, electrochemical unit and Al Electrochemical cell plates

Figure 2. Electrochemical cell with aluminum plates

Source of wastewater: wastewater samples were collected from collection basin of air preheater washing water in Shobra El-Kheima power plant.

Table 1. Wastewater sample analysis (Raw water sample).

No.	Items	Values
1.	**pH**	7.8
2.	**Turbidity (**NTU)	50.9
3.	**Color**	Brown color
4.	**Biochemical oxygen demand BOD (**ppm**)**	549
5.	**Chemical oxygen demand COD (**ppm)	1799
6.	**Hardness of water as $CaCO_3$ (**ppm)	248
7.	**Calcium as $CaCO_3$ (**ppm)	158
8.	**Magnesium as $CaCO_3$ (**ppm)	90
9.	**Alkalinity $CaCO_3$ (**ppm**)**	141
10.	**TDS (**ppm)	2585
11.	**TSS (**ppm**)**	32
12	**Total iron (**ppm**)**	4.4
13	**Oil and Grease (**ppm)	11.45
14	**Organic matter as ($KMnO_4$) ppm**	29.4

Analysis and Method: The water samples were analyzed according to standard method of test (American Society for Testing and materials, 2021)

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System of treatment

Figure (3) showed schematic diagram of the electrocoagulation unit containing industrial wastewater vessel, electrochemical cell (containing DC power source and aluminium electrods), filtration unit and treated water vessel.

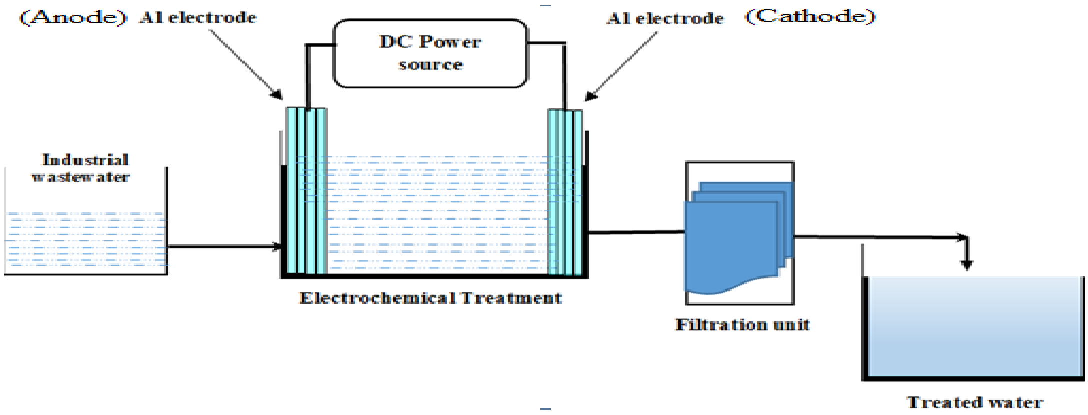

Figure 3. Schematic diagram of treatment plant

The applied current (Amp.) and potential deference (Volt) were changed during the operation of electrochemical unit at different pH values and time. At every change, the turbidity (NTU) of water was determined and percentage removal was calculated according to the following equation:

Removal % = $((C_o - C) / C_o)$ x100

Where C_o and C: are the turbidity (NTU) of raw and treated one.

RESULTS AND DISCUSSION

Before the investigation of the use of electrocoagulation treatment as an alternative technique for the treatment of industrial waste water from power plant, Table 1 displayed the constituents of raw wastewater.

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Effect of applied current and potential difference on the removal of turbidity at different time intervals and pH.

Figures (4) showed the effect of applied current (2, 4, 6, 8, 10 V) on the percentage removal of turbidity in the electrochemical cell at different pH values (2, 4, 6, 8) and the time (3, 6, 9, 12, 15 min) which was measured by stop watch at (0.2) amps.

Increasing the applied volts lead to increase in the percentage removal of turbidity. It was noticed that when the applied volt increased the time to remove the turbidity from the wastewater decreased.

It was also noted that as the pH of the solution increased with constant volt and time, the percentage removal also increased. It can be observed from Figure 4 that the variation of percentage removal of turbidity at 0.2 ampere and pH=2, 4, 6, 8 with increase of current lead to increase the percentage removal of turbidity over the time of the experiment. Time was a factor affecting percentage removal of turbidity which has positive relationship as the time increased the percentage removal increase. Nevertheless, the pH factor is affecting also the percentage removal which indicated that the increasing of pH value led to increase the percentage removal as can be seen in Figure 4. These results were in accordance with those reported previously (Fathy *et al.*, 2020).

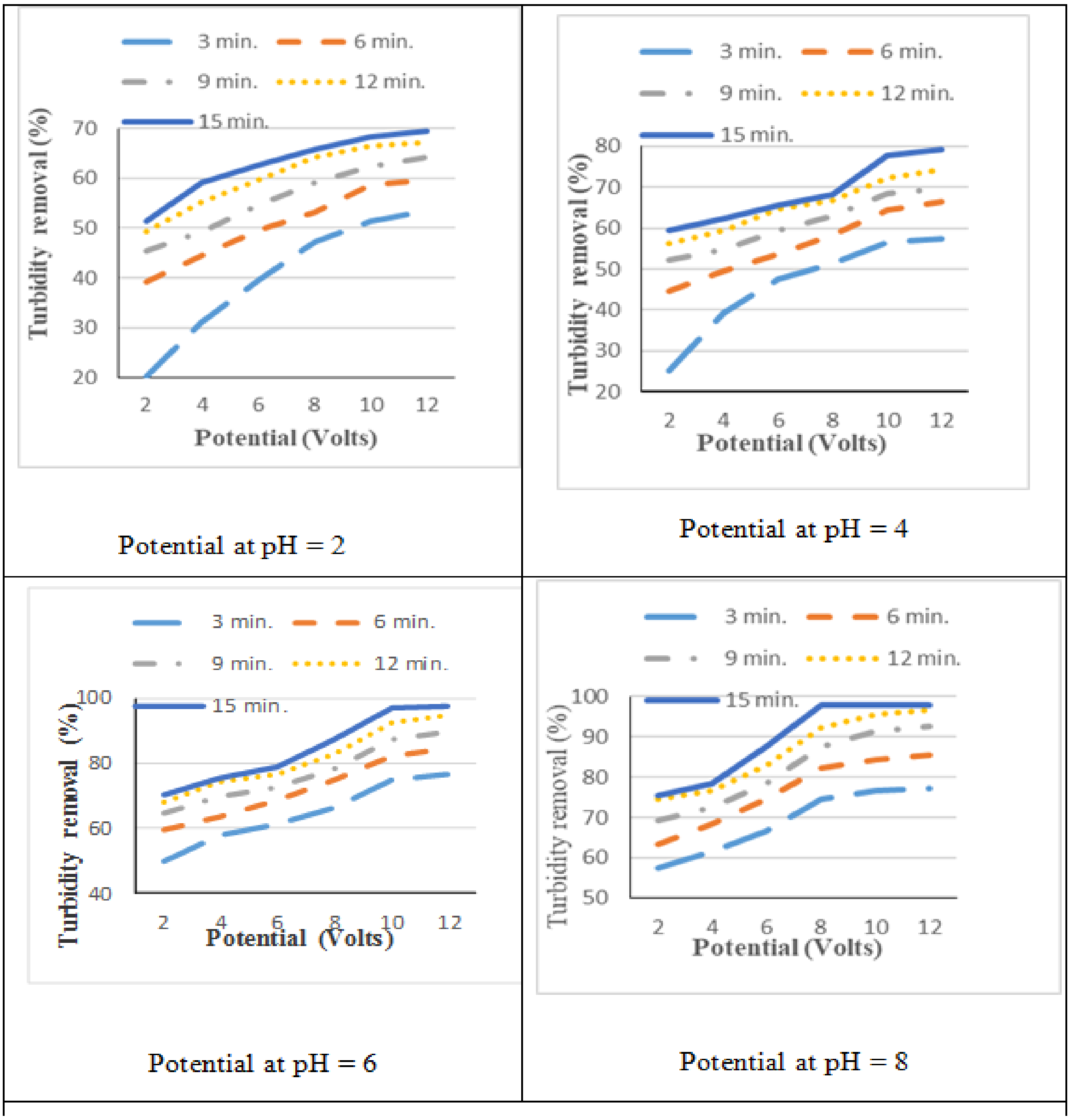

Figure 4. Percentage removal of turbidity at 0.2 ampere and different time intervals potential

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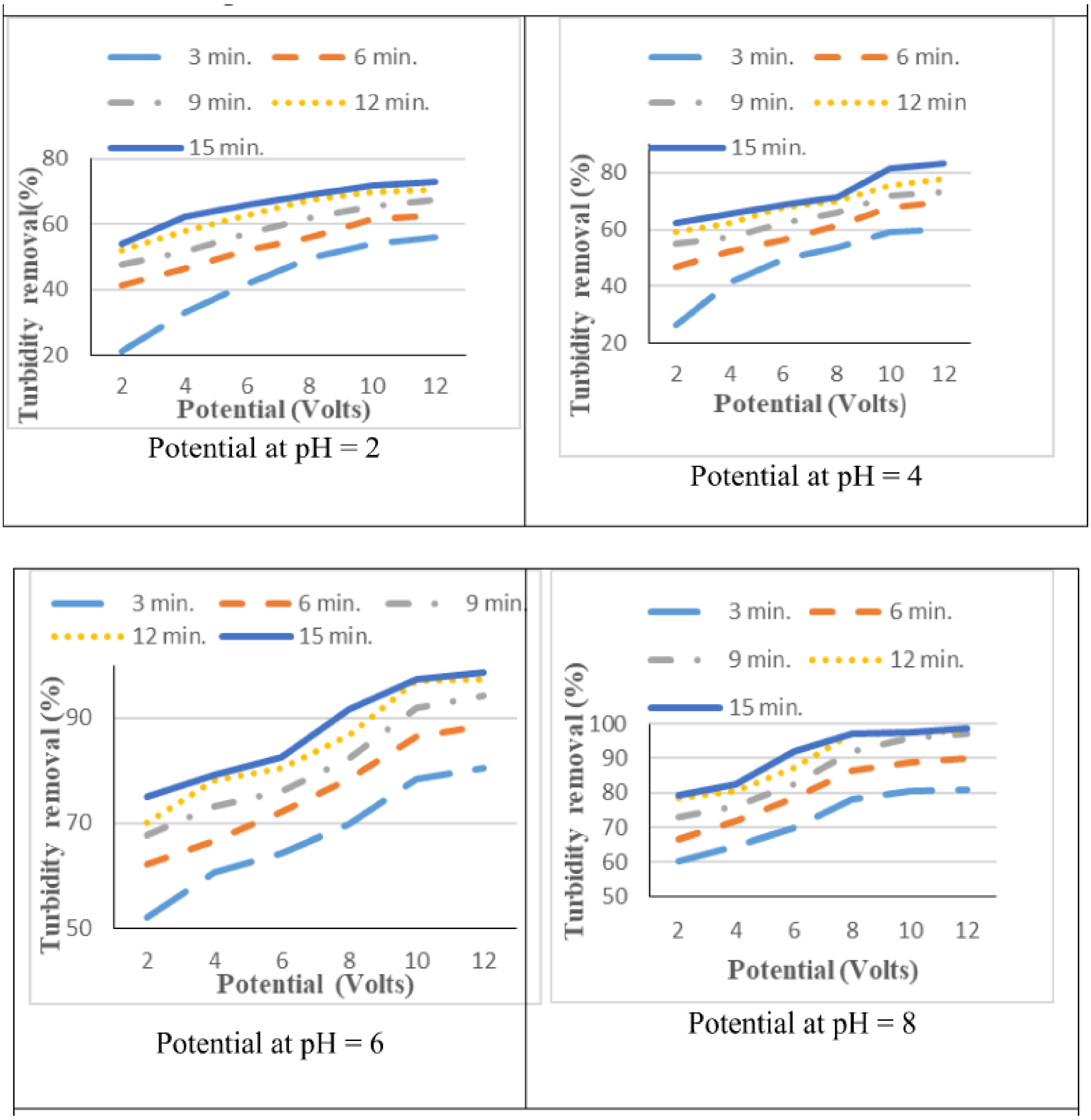

Figure (5) Percentage removal of turbidity at 0.4 ampere and different time intervals potential

Figure (5) showed the change of percentage removal of turbidity at 0.4 ampere and pH=2, 4, 6, 8 for operation time (3, 6, 9,12and 15 min). The results indicate that the increasing of potential leads to increase the percentage removal of turbidity at all time of test. Also, time is a factor affecting percentage removal of turbidity which has positive relationship as the time increased the percentage removal increase. The same trend was found when concerning the effect of pH. The percentage removal increased by increasing of pH value as can be seen from Figure (5).

The percentage removal of turbidity at 0.6 ampere and pH=2, 4, 6, 8 for operation time of (3,6,9,12, and 15 min) were shown in Figure 6. It was observed that the percentage removal increased by increasing of pH value as can be seen from figure 6. In addition, the increasing of current and operation time lead to increase the percentage removal of turbidity at all time of test as can be seen from (Figure 6).

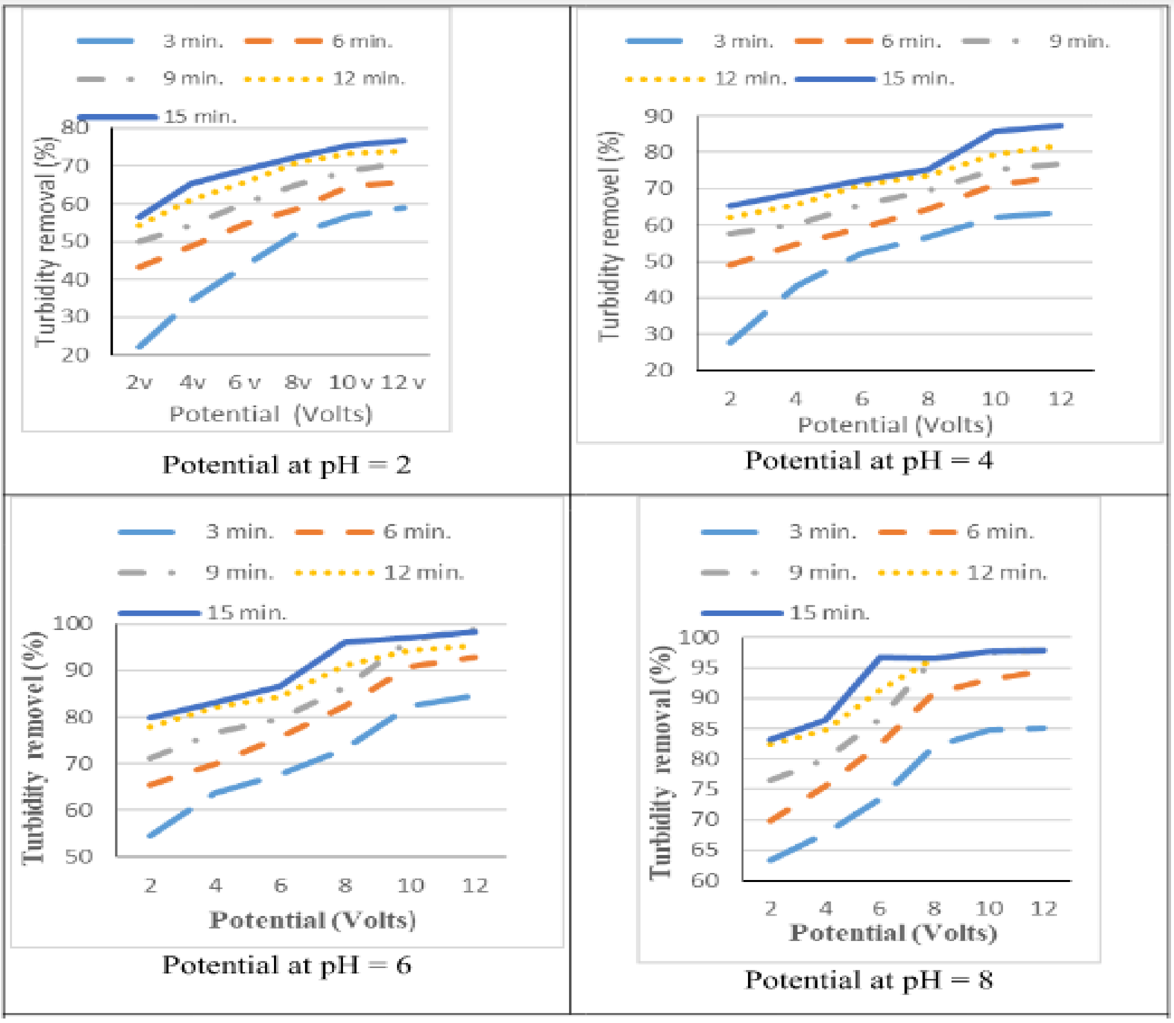

Figure 6. Percentage removal of turbidity at 0.6 ampere and different time intervals potential.

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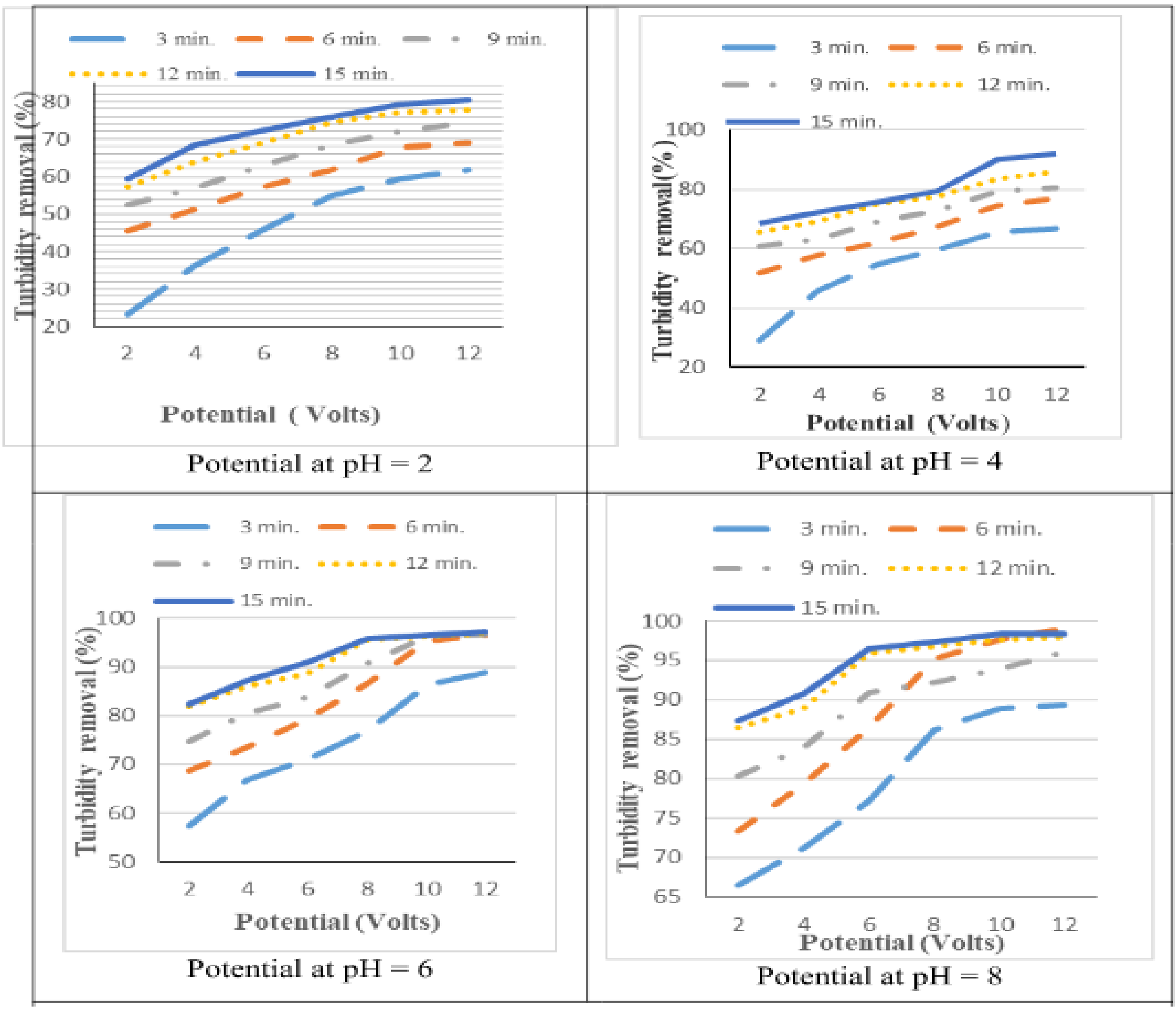

Figure 7. Percentage removal of turbidity at 0.8 ampere and different time intervals potential.

The variation in percentage removal of turbidity at 0.8 ampere and pH=2, 4, 6, 8 were shown in Figure 7. Results indicated that the increase of current lead to increase in the percentage removal of turbidity at all time of test. Time was a factor positively affecting percentage removal of turbidity; as the time increased the percentage removal increase. Similarly, the increasing of pH value led to increase the percentage removal (Figure 7).

From the above-mentioned operation factor, it is clear that the operating current (Volt) and time in addition to pH and potential deference (Amp.) of electrochemical cell had a noteworthy effect on the efficiency of the cell when concerning the percentage removal of turbidity of the industrial waste water for judgment on experiment. These findings are compatible with other works present elsewhere (Fathy et al., 2020). From the above finding the application of the electrocoagulation process proved to be an efficient treatment technology for the removal of turbidity from wastewater (Abouelata et al 2018; Thapa et al., 2015).

The optimum working conditions

According to the above-mentioned results, the optimum conditions for maximum removal of turbidity was at pH = 8, current intensity 0.6 Ampere for duration time of 15 minutes and 10 volts. Therefore, the work was extended to determine the percentage removal of total suspended solids (TSS), biochemical oxygen demands (BOD), chemical oxygen demands (COD), total iron (Fe) and total dissolved solids (TDS) at the optimum condition for different time.

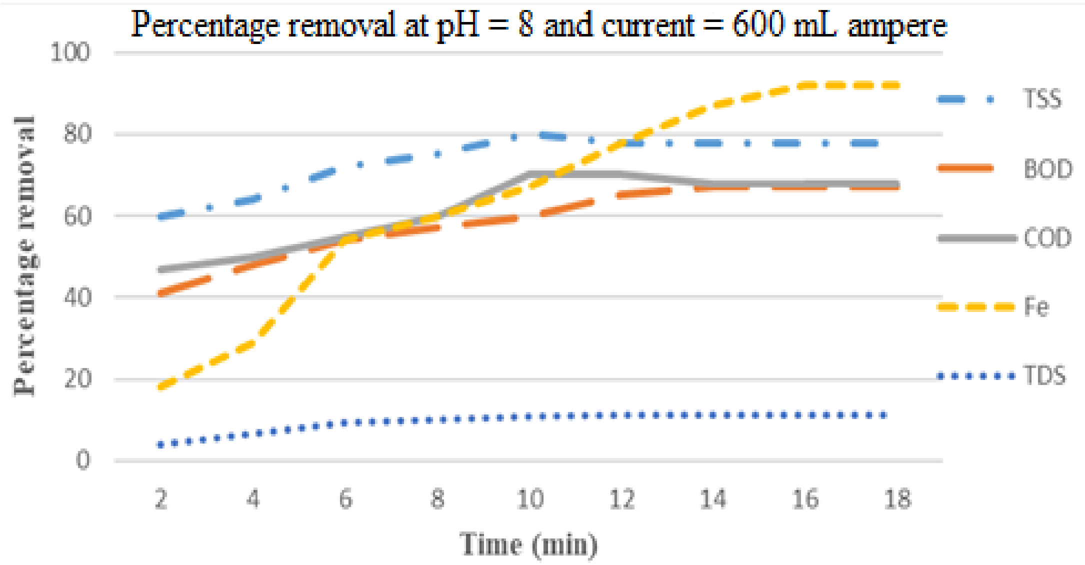

Figure 8. Removal efficiency of TSS, BOD, COD, Fe and TDS at optimum conditions.

Figure (8) showed that the maximum removal of TSS was at 10 minutes which reached to 94.6 %. While for BOD and COD the percentage removal calculated according to (Nayl *et al.* 2017); the maximum removal for BOD was at 14 minutes reached 54.2 % while for COD reached 72.3 % at of 12 minutes. The maximum removal of total iron reached 88.6 %

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at 16 miners and for TDS reached to 28.2 % at 14 minutes. The obtained results were similar to those recorded previously by Thapa et al., 2015.

Energy consumption of electrochemical cell

The electrocoagulation cell energy consumption (E) can be calculated using the following equation (Abouelata *et al.,* 2018).

The energy consumed per one litre as flow:

Energy consumption (E) = ¼ Volt (V) x Current (A) x Time (sec).

E= ¼ 12 x 0.8 x (12x60) = 648 j L^{-1}

E = 648 / 1000 x 3600 = 0.00018 KW l^{-1}

The results revealed that the electrochemecal consumed low amount of energy as that reported by Abouelata et al., (2018).

Effect of electrocoagulation on the treatment of wastewater

Results obtained at the optimum conditions in electrochemical cell (pH 8 volts and 0.8 amp.) were given in Table 2. The removal effeciency of turbidity and TSS reached 94% and 94.6% respectively. These results are in agreement with that recorded by Grich *et al.* (2019) for minicipal wastewater treatment, as they reported 88 and 91% for turbidity and TSS respectively. The results of the present investigation gave better results than those reported by Ahmadzadeh.S *et al.* (2017) for leather production wastewater (53.6%) for TSS. The BOD reached to 54.2%. The percentage removal of (COD) reached 72.3% which is comparable to that recorded by Maitlo *et al.* (2019) for COD (81.9%). The total iron maximum removal reached 88.6%, while it reached 28.2 % for TDS. These results were in partial agreement with those reported by Ahmadzadeh.S *et al.* (2017) for liter production wastewater.

Table (2) Effect of electrocoagulation on the treatment of wastewater

Parameters	Raw Industrial wastewater	Treated water
pH	7.8	**7.6**
Turbidity (NTU)	50.9	**3.9**
Color	Dark brown	**Clear**
Biochemical oxygen demand BOD (ppm**)**	549	**251**
Chemical oxygen demand COD (ppm)	1799	**498**
Hardness of water as $CaCO_3$ (ppm)	248	**149**
Calcium as $CaCO_3$ (ppm)	158	**87**
Magnesium as $CaCO_3$ (ppm)	90	**62**
Alkalinity $CaCO_3$ (ppm**)**	141	**131**
TDS (ppm)	2585	**1855**
TSS (ppm**)**	32	**1.7**
Total iron (ppm**)**	4.4	**0.5**
Oil and Grease (ppm)	11.45	**3.11**
Organic matter as ($KMnO_4$) (ppm)	29.4	**6.3**

CONCLUSIONS

This work was done to evaluate the efficiency of removing several contaminants from wastewater, including BOD, COD, turbidity, iron, TDS and TSS by using electrochemical coagulation technique as lab scale unit. The percentage removal efficiency of water contaminants was found to be acceptable. Results obtained showed that the optimum working conditions of electrochemical cell are pH = 8, 12 volts and 0.8 amp. The maximum removal of turbidity 94% at 10 minutes. Other contaminants such as (TSS) was 94.6% at 10 minutes, while for (BOD) 54.2% at 14 minutes. Also, the percentage removal of (COD) reached to 72.3% at 12 minutes. In regard to total iron, the maximum removal reaches to 88.6% at 16 minutes.

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معالجة المخلفات السائلة لمحطات القوى الكهربية بشبرا الخيمة باستخدام التخثر الكهروكيميائي

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المستخلص

يتناول هذا البحث استخدام تقنية التخثر الكهروكيميائى في معالجة المياه الصناعية الناتجة من محطات القوى الكهربائية. حيث تم دراسة أثر عوامل التشغيل لوحدة التخثر الكهروكيميائي (المشيدة معمليا) حيث تم مقارنة هذه العوامل (شدة التيار، جهد التيار، الأس الهيدروجيني، الزمن) على إزالة ملوثات مياه الصرف الصناعى الناتجة عن صرف محطات الكهرباء وفيها اثر شدة التيار المستخدم و فرق الجهد الواقع على الواح خلية التخثر على نسبة إزالة كل من المواد الصلبة الذائبة والعالقة TSS–TDS حيث وصلت إلى28.2 % و 94.6% على التوالي. بالإضافة إلى كل من الأكسجين الحيوى والكيماوى المستهلك BOD و COD وصلت نسبة الإزالة لهم إلى 54.4% – 72.3% على التوالي. قد تم إزالة 88.6% من الحديد الكلي بالمياه وأيضا تم إزالة أكثر من 94% من العكارة المتواجدة في مياه الصرف الصناعي. بالإضافة إلى ذلك فقد أظهرت النتائج ايضا أن افضل ظروف تشغيل كانت عند , pH=8 ,12volt 0.8Amp

كلمات مفتاحية: التخثر الكهروكيميائي، مياه الصرف، المخلفات السائلة، محطات القوى الكهربية، أقطاب الالومنيوم