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Removal of TOC from fertilizer production wastewater by electrooxidation

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ABSTRACT

Treatment of fertilizer production wastewater was investigated by electrooxidation (Eox) process using graphite as the anode electrode and NaCl as the supporting electrolyte. In the studies, graphite anode and titanium cathode electrodes were used in direct oxidation, and together with the addition of NaCl, direct oxidation and indirect oxidation were applied to break the polluters and, therefore, remove total organic carbon (TOC) from fertilizer production wastewater. The effects of operating conditions such as pH, supporting electrolyte (NaCl), current density, and time on the removal efficiency of TOC were investigated. In addition, the specific energy consumption (SEC) for TOC removal performance was calculated. The experimental results showed that at pH 4, 8,000 mg/L NaCl, 360 min. and 62.5 mA/cm^2 applied current density for an initial TOC 950 mg/L, TOC removal, and SEC were found to be 82.1% and 492.3 kWh/kg TOC$_{rem}$, respectively. According to these results, the supporting electrolyte (NaCl) was found to be very effective for the removal of TOC in the Eox process.

Keywords: Fertilizer production wastewater; Electrooxidation; TOC removal; Supporting electrolyte NaCl; Specific energy consumption

1. Introduction

The main wastewater origin of the liquid fertilizer production plant is in the cleaning of the reactor where water is used for general washing and cleaning. These processes require large quantities of water and also produce plenty of wastewater. These wastewaters are characterized by high chemical oxygen demand (COD), total organic carbon (TOC) contents of organic matter, total nitrogen (TN), and total phosphorus [1]. Hence, the fertilizer production wastewater must be treated before being discharged into the environment due to the conservation of water sources and natural life.

Recent research has shown that electrochemical techniques can offer a good opportunity to prevent and remedy pollution problems due to strict environmental regulations. The use of electrochemical technologies for the treatment of organic pollutants contained in industrial wastewaters has received a great deal of attention in recent years [2]. The removal of TOC by electrooxidation (Eox) in the presence of NaCl was investigated for various organic pollutants and wastewater.

The removal of atrazine and TOC was only achieved at appreciable rates when NaCl was used as the supporting electrolyte, due to the oxidizing species formed in this electrolyte (e.g. ClO^-). Variation of the NaCl concentration demonstrated that although only low concentrations of NaCl are necessary to result in the complete removal of atrazine in solution, TOC removal is almost linearly dependent on the quantity of NaCl in solution. Examination of the applied current density indicates that the efficiency of TOC removal reaches a maximum at 60 mA/cm^2 [3]. Azo/dichlorotriazine reactive dye mineralization study was also carried out on a concentrated dyebath. For 1,000 mg/L dye concentration, TOC removal of 81% was obtained with 20,000 mg/L NaCl concentration, 24 mA/cm^2 current density, and 10 h treatment time [4]. Electrodegradation of landfill leachate in a flow electrochemical reactor was investigated. At a current density of 116 mA/cm^2, 180 min of processing, and in the presence of 2,800 mg/L Cl^-, the removal rates achieved were 73% for COD and 57% for TOC [5]. A complete color removal with 73.5% COD and 32.8% TOC removals was obtained for mixed reactive dyes (200 mg/L) at the end of 120 min of electrolysis under the optimum operating conditions of 4,000 mg/L NaCl concentration and 72.2 mA/cm^2 current density [6].

Eox, electrocoagulation (EC), and electro-Fenton are widely used electrochemical treatment technologies. Electrochemical treatment methods such as Eox and EC are known as high efficiency, effective, eco-friendly, and cost-effective processes [7–17].

There have been few studies, in which Eox was applied to fertilizer production wastewater and the specific energy consumption (SEC) for TOC removal performance was calculated. With this study, it would be possible to see the TOC removal performance of fertilizer production wastewater by Eox process using graphite as the anode electrode and NaCl as the supporting electrolyte and to analyze the effects of operation parameters and the SEC.

The aim of this study was to investigate TOC removal by Eox of fertilizer production wastewater and to optimize the treatment process for the effects of operating parameters such as pH, NaCl concentration, current density, and electrolysis time.

2. A brief description of Eox

In Eox, pollutants can be removed by direct electrolysis or indirect electrolysis. In direct electrolysis, pollutants exchange electrons directly with the anode surface without the involvement of other substances. In indirect electrolysis, organic pollutants do not exchange electrons directly with the anode surface but rather through the mediation of some electroactive species regenerated there which act as intermediaries for the electrons shuttling between the electrode and the organic compounds. Indirect electrolysis can be a reversible or an irreversible process, and the redox reagent can be electrogenerated by either anodic or cathodic processes. Process selection depends on the nature and structure of the electrode material, experimental conditions, and electrolyte composition [18]. The general principle of direct and indirect oxidation is illustrated in Fig. 1.

Oxidation mediators can be metallic redox couples, such as Ag(II), Ce(IV), Co(III), Fe(III), and Mn(III) or strong oxidizing chemicals, such as active chlorine, ozone, hydrogen peroxide, persulfate, percarbonate, and perphosphate. Among anodically generated oxidizing chemicals, active chlorine is the most traditional one and the most widely employed for wastewater treatment [18]. The general reaction of Eox for direct and indirect oxidation when chlorine is used as the mediator is listed in Table 1.

3. Materials and methods

3.1. Wastewater characteristics

The study is carried out on the treatment of the fertilizer production wastewater. The wastewater has a high organic content, suspended solid, and green color. Filtered wastewater has a 950 mg/L TOC content. The wastewater characteristics are listed in Table 2.

3.2. Chemicals and analytical method

All the chemicals (H_2SO_4 and NaOH were used to arrange pH and NaCl as the supporting electrolyte) used in the experiments were analytical quality Merck products.

All the chemical analyses were carried out in accordance with the standard methods for examination of water and wastewater [19]. TOC was determined through combustion of the sample at 750°C using a non-dispersive IR source (Teledyne Tekmar Torch Combustion) TOC/TN analyzer. All the experiments were repeated twice, for minimizing error in experiments

Fig. 1. Direct and indirect oxidation of pollutants.

Table 1
General reaction of electrooxidation for direct and indirect oxidation

Eox method	Main electrodic reaction	Main reaction in liquid
EOx direct oxidation		
(selective)	$MO_x + (OH^\bullet) \rightarrow MO_{x+1+}H^+ + e^-$	$R + MO_{x+1} \rightarrow RO + MO_x$
(non selective)	$MO_x + H_2O \rightarrow MO_x(OH^\bullet) + H^+ + e^-$	$n MOx(OH^\bullet) + R \rightarrow {}^n/_2CO_2 + ze^- + zH^+ + n MO_x$
EOx indirect oxidation		
(Oxygen as mediator)	$O_2 + 2H_2O + 4e^- \rightarrow H_2O_2$	$H_2O_2 \rightarrow HO^\bullet{}_2 + H^+ + e^-$ $RH + HO^\bullet{}_2 \rightarrow ROH + OH^-$
(Chlorine as mediator)	$2Cl^- \rightarrow Cl_2 + 2e^-$	$Cl_2 + H_2O \rightarrow HOCl + H^+ + Cl^-$ $HOCl + R \rightarrow ROH + Cl^-$
R: organic pollutant		

Table 2
Wastewater characteristics

Parameter	Unit
TOC, mg/L	950
COD, mg/L	2,740
TN, mg/L	15
TSS (total suspended solids) mg/L	105
Conductivity, mS/cm	7.9
pH	5.7

results, the maximum experimental error was below 4% and the average values have been reported.

3.3. Experimental apparatus and procedure

A single compartment electrochemical cell (Eox reactor), made of plexiglass with dimensions of 80 mm × 80 mm × 100 mm and a 500 mL working capacity, was employed. Two electrodes of the same dimensions of 67 mm × 60 mm; one graphite anode and one stainless steel cathode electrode were used in the reactor. The total effective anode electrode area was 40 cm^2, and the distance between electrodes was 50 mm. The typical properties of graphite electrode (Tokai Carbon Co., Tokai Isotropic Graphite G347) are listed in Table 3. The experimental setup is shown in Fig. 2.

In each run, 500 mL of the wastewater was placed into the reactor after adjusting to a desired pH and NaCl concentration value using H_2SO_4 or NaOH solutions and pure NaCl and was agitated using a magnetic stirrer at 250 rpm (Heidolph MR Hei-Tec model). The current density was adjusted to a desired value, and the run was started. At the end of the run, the solution was filtered. In the experiments, a digital D.C. power supply (Agilent U8032A Triple Output System; 0–60 V/0–3A (2X) & 5 V/3A) was used. The temperature was measured using digital thermometer.

Table 3
The typical properties of graphite electrode

Specific gravity	1.85	g/cm^3
Specific resistance	11.0	μΩm
Young's modulus	10.8	Gpa
Flexural strength	49.0	Mpa
Tensile strength	31.4	Mpa
Shore hardness	58	sHD
Thermal conductivity	116	W/mK
Pore size	2.5	μm
Porosity	12	%
Grain size	11	μm
Gas permeability	0.30	cm^2/s

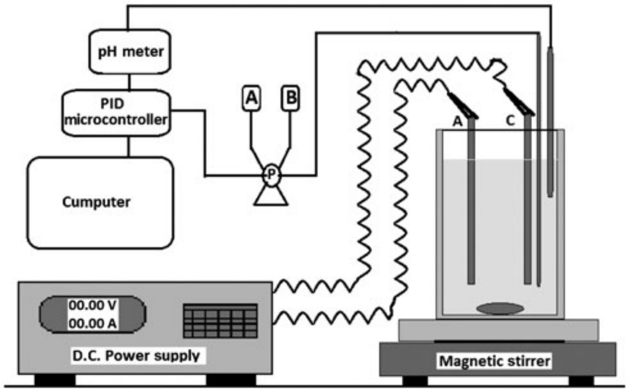

Fig. 2. Schematic diagram of experimental set-up.

4. Results and discussion

4.1. TOC removal performance of the Eox process

The oxidation of organics in the presence of chloride ions mainly depends on chloride concentration, solution temperature, and pH; and it is substantially insensitive to electrode surface nature [18]. The effects of pH, NaCl concentration, current density, and electrolysis time were investigated in order to determine the preliminary optimum operating conditions for high removal efficiency of TOC.

To investigate the TOC removal performance by Eox process, a graphite anode electrode was used. Carbon and graphite electrodes are very cheap and have a large surface area so they have been widely used for the removal of organics in electrochemical reactors with three-dimensional electrodes (e.g. packed bed, fluidized bed, carbon particles, porous electrode, etc.). However, with these materials, Eox is generally accompanied by surface corrosion, especially at high current densities [20]. To reduce the corrosion of graphite, high-strength graphite was used. Thus, the anodic corrosion of graphite is reduced. At the end of the study, the thickness of graphite anode decreased from 8 to 6.8 mm. 1.2 mm corrosion was observed on the surface of graphite anode. Typical properties of this graphite are listed in Table 3.

4.1.1. Effect of pH

pH is an important operating factor influencing the performance of the Eox process. In the Eox process, especially where strong oxidants like active chloride are used, free chloride, hypochlorites, and chlorates of different ratios are produced depending on the pH [21].

During Eox studies, it is known that if a pH check is not made, the initial pH changes dramatically and later on various ions in the solution are stabilized at a certain point depending on the buffering capacity [22]. Taking this reality into consideration, during the runs, the pH of the wastewater was controlled at the desired value within 0.2 pH unit accuracy by means of a process control system consisting of a PID microcontroller, acid and base dosing pumps, and a pH sensor with a response time of 3 s.

The effect of pH (4, 6, 8, 10, and 12) was investigated while holding constant the current density (37.5 mA/cm^2), NaCl concentration 4,000 mg/L and operating time within a range of 30–360 min. The effect of the pH on the TOC removal efficiency is shown in Fig. 3. The percentage TOC removal efficiency decreased as the pH increased. While the removal efficiency reached the highest value (82.2%) at pH 4, it decreased dramatically (10.5%) at pH 12, at the end of the operating time. Looking at the overall TOC removal, it was high under acidic conditions and low under basic conditions.

Indirect electrochemical treatment involves the application of an electrical current to wastewater containing chloride to convert chloride to chlorine/hypochlorite. The chlorine/hypochlorite oxidizes the pollutants and is then reduced to chloride ion.

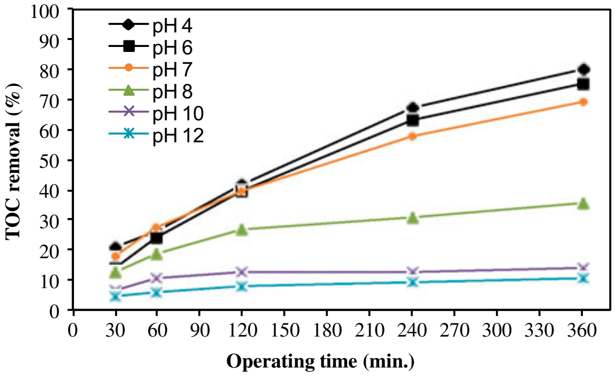

Fig. 3. Effect of pH on TOC removal efficiency of the Eox process.

$$\text{Anode}: 2Cl^- \rightarrow Cl_2 + 2e^- \quad (1)$$

$$\text{Cathode}: H_2O + 2e^- \rightarrow H_2 + 2OH^- \quad (2)$$

Chlorine formed at the electrode (Cl_2) can undergo a dismutation reaction in the bulk solution (Cl_2) to form hypochlorous acid or hypochlorite ion, depending on whether the pH is low or high, respectively:

$$\text{Bulk solution}: Cl_2 + H_2O \rightarrow HOCl + H^+ + Cl^- \quad (3)$$

$$HOCl \rightarrow H^+ + OCl^- \quad (4)$$

While the pH increased from 4 to 12, TOC removal decreased especially drastically at pH 10 and 12. The reason may be due to the decreased production of chlorine/hypochlorite at higher pH conditions, because of the formation of chlorate or perchlorate according to the following equation:

$$6HOCl + 3H_2O \rightarrow 2ClO_3^- + 4Cl^- + 12H^{+3/2}\, O_2 + 6e^- \quad (5)$$

$$ClO_3^- + H_2O \rightarrow ClO_4^- + 2H^+ + 2e^- \quad (6)$$

Another reason may be that at acidic pH, the chlorine is present in the solution in the form of hypochlorous acid (HOCl), which has higher oxidation potential (1.49 V) than that of hypochlorite (OCl^-) (0.94 V). The hypochlorite is prevalent in alkaline conditions [23].

The electrochemical cell temperature was observed to increase during run time. The temperature increased from 20 to 40°C for pH 4, 6, 7, and 8 and from 20 to 35°C for pH 10 and 12.

4.1.2. Effect of NaCl concentration

The effect of NaCl concentration was investigated within a range of 0–16,000 mg/L while holding constant the current density (37.5 mA/cm^2) at pH 4 and operating time within a range of 30–360 min. Depending on the amount of NaCl added to the wastewater conductivity increases. This increase was measured (7.9 mS/cm for 0 mg/L NaCl, 34.2 mS/cm for 16,000 mg/L NaCl). The effect of NaCl concentration on the TOC removal efficiency of the Eox process is shown in Fig. 4. During the Eox process in the absence of NaCl, only 28.9% TOC removal was noted. When the Eox process was repeated with the addition of NaCl, it showed a marked increase in the TOC removal rate. This increase was due to the mediation of active chlorine electrogenerated on the anode surface by chloride oxidation according to equations 3 and 4. While the removal efficiency depending on the NaCl concentration increased, it reached a stable state for 8,000 and 16,000 mg/L, and it reached the highest value (80.6%) at 8,000 mg/L.

Increasing the NaCl up to 8,000 mg/L accelerated the TOC removal rate. A further increase in the NaCl concentration to 16,000 mg/L did not bring about any meaningful improvements, and so, the optimum NaCl concentration used in the successive experiments was 8,000 mg/L.

The electrochemical cell temperature was observed to increase during run time. The temperature increased from 20 to 44°C for 0 mg/L NaCl and from 20 to 34°C for 16,000 mg/L NaCl. The increasing of NaCl concentration increased the conductivity of the solution (wastewater). The resistance of the solution decreased when the conductivity of solution increased. Therefore, the temperature of the electrochemical cell decreased when the NaCl concentration increased.

4.1.3. Effect of current density

The effect of current density was investigated within a range of 12.5–62.5 mA/cm^2 while holding constant the NaCl concentration at 8,000 mg/L, pH 4, and operating time within a range of 30–360 min. The effect of current density on the TOC removal efficiency of the Eox process is shown in Fig. 5. While the removal efficiency increased depending on the current density increase, it reached a stable state at the end of the operating time of 360 min. for current density (J) 37.5, 50, and 62.5 mA/cm^2 and it reached the highest value (82.1%) at 62.5 mA/cm^2.

While the removal efficiency increased with a decelerating increase depending on duration increase, it reached 62.1% in the 120th minute and 82.1% in the 360th minute.

The electrochemical cell temperature was observed to increase during run time. The temperature increased from 20 to 25°C for 12.5 mA/cm^2 current density and from 20 to 49°C for 62.5 mA/cm^2 current density.

4.2. The SEC for TOC removal performance

The SEC is the dominant component of the running costs of most electrochemical treatment processes. The applied potential and current are very important for evaluating the economic aspect of the systems. The applied potential, current, and dissolution of the electrodes directly affect the aspects of cost and efficiency of the process. The SEC is defined as the amount of energy consumed per unit mass of TOC removed (TOC$_{rem}$) and expressed in kWh/kg of TOC removed and is given as:

$$\mathrm{SEC} = (V^* I^* t)/\mathrm{TOC_{rem}} \tag{7}$$

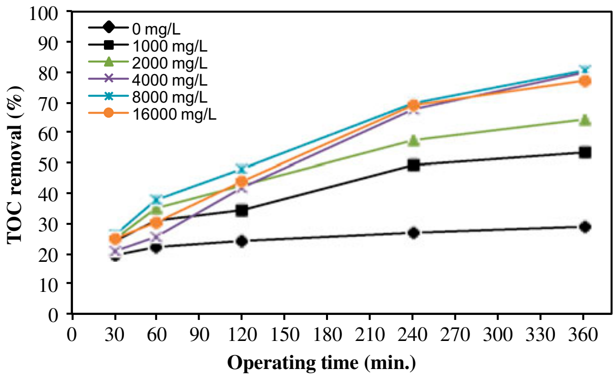

Fig. 4. Effect of NaCl concentration on TOC removal efficiency of the Eox process.

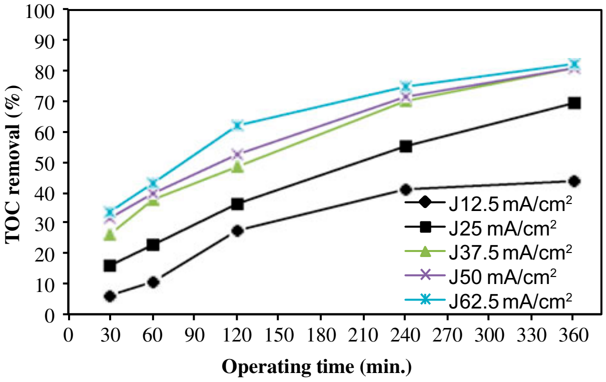

Fig. 5. Effect of current density on TOC removal efficiency of the Eox process.

where V is the voltage across the electrodes, I is the current in amperes, t is the time in hours, and TOC_{rem} is the TOC removal.

4.2.1. The SEC for pH

The applied current (A), potential (Voltage, V), and TOC removed percentage (TOC_{rem}) are given, and the SEC values for pH are calculated and listed in Table 4.

The SEC value (kWh/kg TOC_{rem}) increased, respectively, from 277.4 to 319.1, 546.7, 1347.5, and 1750.4 when the pH of the wastewater increased, respectively, from 4 to 6, 8, 10, and 12. The effect of pH on the SEC value (kWh/kg TOC_{rem}) is shown in Fig. 6. In the Eox process, the SEC value (kWh/kg TOC_{rem}) was calculated, respectively as 277.4 for pH 4 and 1750.4 for pH 12. The percentage TOC removal efficiency decreased with increasing pH. Due to this effect, the amount of SEC increased up to about 7 times.

Table 4
The SEC values for pH

Run	Time (min)	Voltage (V)	Current (A)	TOC_{rem}%	SEC, kWh/kg TOC_{rem}
pH 4	30	14.15	1.5	21.10	105.89
	60	12.25	1.5	25.90	149.36
	120	11.43	1.5	41.80	172.70
	240	12.80	1.5	67.50	239.53
	360	11.74	1.5	80.20	277.36
pH 6	30	14.25	1.5	14.20	158.45
	60	12.85	1.5	24.20	167.68
	120	12.45	1.5	39.40	199.57
	240	13.80	1.5	62.90	277.13
	360	12.70	1.5	75.40	319.14
pH 8	30	11.50	1.5	12.60	144.11
	60	11.00	1.5	18.90	183.79
	120	10.28	1.5	26.80	242.26
	240	11.40	1.5	30.60	470.59
	360	10.30	1.5	35.70	546.66
pH 10	30	12.09	1.5	6.53	292.34
	60	11.20	1.5	10.80	327.49
	120	10.80	1.5	12.60	541.35
	240	10.50	1.5	12.70	1044.34
	360	10.17	1.5	14.30	1347.52
pH 12	30	11.70	1.5	4.74	389.74
	60	10.50	1.5	6.32	524.65
	120	10.10	1.5	7.89	808.49
	240	9.90	1.5	9.47	1320.51
	360	9.70	1.5	10.50	1750.38

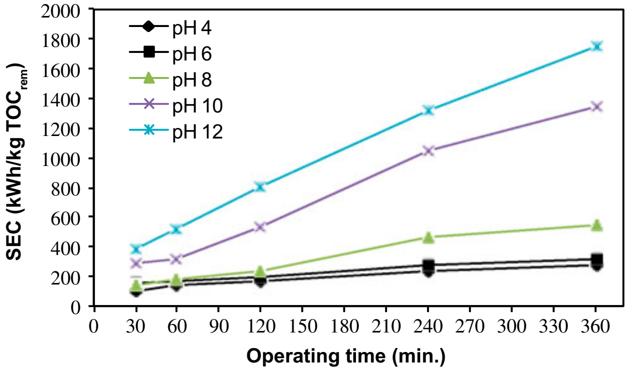

Fig. 6. Effect of pH on SEC.

4.2.2. The SEC for NaCl concentration

The applied current (A), potential (Voltage, V), and TOC removed percentage (TOC_{rem}) are given, and the SEC values for NaCl concentration are calculated and listed in Table 5.

The cell voltage decreased, respectively, from 14.33 to 14.30, 13.20, 11.74, 9.25, and 7.50 V when the concentration of chloride increased, respectively, from 0 to 1,000, 2,000, 4,000, 8,000, and 16,000 mg/L. This decrease was due to the increase in conductivity of the solution because of the addition of the supporting electrolyte. As a result of this, power consumption during the treatment of wastewater decreased.

The effect of NaCl concentration on the SEC value (kWh/kg TOC_{rem}) is shown in Fig. 7. During the Eox process, in the absence of NaCl, the SEC value (kWh/kg TOC_{rem}) was calculated as 939.5. When the Eox process was repeated with the addition of 16,000 mg/L NaCl, the SEC value (kWh/kg TOC_{rem}) was calculated as 183.8.

While the NaCl reduced energy consumption, it also increased the removal efficiency. With this dual effect, NaCl reduced the amount of SEC by up to about 5 times.

4.2.3. The SEC for current density

The applied current (A), potential (Voltage, V), and TOC removed percentage (TOC_{rem}) are given, and the SEC values for current density are calculated and listed in Table 6.

The cell voltage increased, respectively, from 5.40 to 7.35, 9.25, 11.20, and 12.80 V when the current density increased, respectively, from 12.5 to 25, 37.5, 50, and 62.5 mA/cm^2. As a result of this, power consumption during the treatment of wastewater increased.

Table 5
The SEC values for NaCl concentration

Run	Time (min)	Voltage (V)	Current (A)	TOC_{rem}%	SEC, kWh/kg TOC_{rem}
NaCl (0 mg/L)	30	16.60	1.5	19.70	133.05
	60	15.40	1.5	22.10	220.05
	120	14.55	1.5	24.20	379.73
	240	14.40	1.5	26.80	678.71
	360	14.33	1.5	28.90	939.50
NaCl (1,000 mg/L)	30	16.40	1.5	24.20	107.00
	60	15.25	1.5	31.40	153.37
	120	14.39	1.5	34.70	261.91
	240	14.40	1.5	49.30	368.96
	360	14.30	1.5	53.70	504.56
NaCl (2,000 mg/L)	30	15.25	1.5	24.80	97.09
	60	14.45	1.5	35.30	129.27
	120	13.95	1.5	42.60	206.82
	240	13.45	1.5	57.40	295.89
	360	13.20	1.5	64.40	388.36
NaCl (4,000 mg/L)	30	14.15	1.5	21.10	105.89
	60	12.25	1.5	25.90	149.36
	120	11.43	1.5	41.80	172.70
	240	12.80	1.5	67.50	239.53
	360	11.74	1.5	80.20	277.36
NaCl (8,000 mg/L)	30	9.90	1.5	26.30	59.44
	60	9.64	1.5	37.90	80.32
	120	9.36	1.5	48.40	122.14
	240	9.25	1.5	70.10	166.68
	360	9.25	1.5	80.60	217.45
NaCl (16,000 mg/L)	30	7.80	1.5	25.30	48.68
	60	7.45	1.5	30.50	77.14
	120	7.34	1.5	44.20	104.88
	240	7.50	1.5	68.80	137.70
	360	7.50	1.5	77.30	183.84

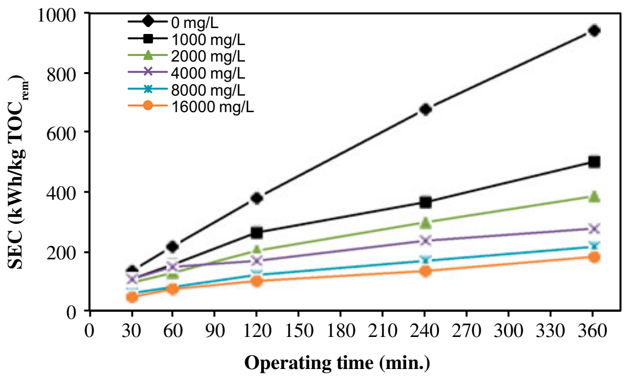

Fig. 7. Effect of NaCl concentration on SEC.

The effect of current density on the SEC value (kWh/kg TOC_{rem}) is shown in Fig. 8. In the Eox process, SEC value (kWh/kg TOC_{rem}) is calculated, respectively as 77.5 for 12.5 mA/cm^2 current density and 492.3 for 62.5 mA/cm^2 current density. The percentage TOC removal efficiency increased with increasing current density. In addition, SEC value (kWh/kg TOC_{rem}) increased up to about 6.4 times.

Increasing the current density up to 37.5 mA/cm^2 accelerated the TOC removal rate. A further increase in the current density to 50 and 62.5 mA/cm^2 did not bring about any meaningful improvements, and so, the optimum current density was realized as 37.5 mA/cm^2.

When current density was applied, respectively as 25, 37.5, and 50, for the removal of approximately 70% TOC 134.4, 166.7, and 266.5 kWh/kg TOC_{rem}, the SEC value was calculated. As can be seen, the high current density applied to the unit of energy used for the removal of TOC steadily increased. Moreover, the high current density increased the dissolution of the anode and reduced the life of electrodes like graphite.

Table 6
The SEC values for current density

Run	Time (min)	Voltage (V)	Current (A)	TOC_{rem}%	SEC, kWh/kg TOC_{rem}
J 12.5 mA/cm^2	30	5.42	0.5	6.30	45.28
	60	5.41	0.5	10.80	52.73
	120	5.40	0.5	27.40	41.49
	240	5.40	0.5	40.70	55.87
	360	5.40	0.5	44.00	77.51
J 25 mA/cm^2	30	7.77	1.0	15.80	51.77
	60	7.50	1.0	22.70	69.56
	120	7.40	1.0	36.00	86.55
	240	7.35	1.0	55.10	112.33
	360	7.35	1.0	69.10	134.36
J 37.5 mA/cm^2	30	9.90	1.5	26.30	59.44
	60	9.64	1.5	37.90	80.32
	120	9.36	1.5	48.40	122.14
	240	9.25	1.5	70.10	166.68
	360	9.25	1.5	80.60	217.45
J 50 mA/cm^2	30	13.86	2.0	31.60	92.34
	60	11.63	2.0	40.00	122.42
	120	11.50	2.0	52.60	184.11
	240	11.25	2.0	71.10	266.49
	360	11.20	2.0	81.10	348.89
J 62.5 mA/cm^2	30	15.05	2.5	33.70	117.52
	60	12.65	2.5	43.20	154.12
	120	12.20	2.5	62.10	206.80
	240	12.70	2.5	74.70	357.92
	360	12.80	2.5	82.10	492.34

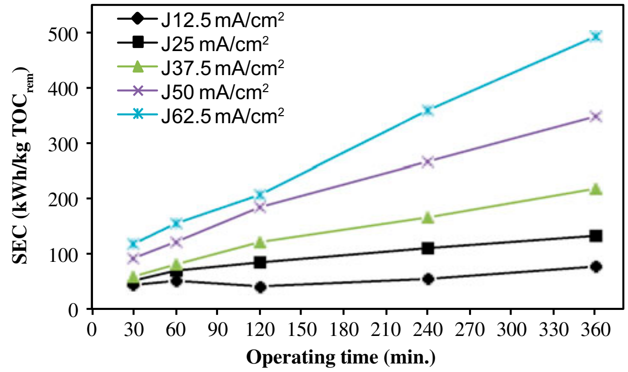

Fig. 8. Effect of current density on SEC.

However, it must be remembered that the use of NaCl as the supporting electrolyte in the Eox process directly affects removal efficiency and cost.

5. Conclusion

TOC describes the amount of organic compounds in wastewater and is used as a more convenient and direct expression of the total organic content than either biological oxygen demand (BOD) or COD [19]. For fertilizer production wastewater, TOC measurement provides practical information about the wastewater sample because the organic matter content is usually high.

TOC removal from fertilizer production wastewater was achieved by Eox process using graphite as the anode electrode and NaCl as the supporting electrolyte.

Treatment of fertilizer production wastewater was investigated under all conditions tested in terms of the effect of pH from 4 to 12, NaCl concentration from 0 to 16,000 mg/L as the supporting electrolyte and applied current density from 12.5 to 62.5 mA/cm^2.

The experimental results allowed us to obtain the best results for TOC removal (82.1%) at pH 4, in the presence of 8,000 mg/L NaCl supporting electrolyte, when current density was applied for 62.5 mA/cm^2 at the end of 360 min. SEC value was calculated to be 492.3 kWh/kg TOC_{rem} for 82.1% TOC removal. Moreover, the optimum current density was realized as 37.5 mA/cm^2 and, at this point, SEC value was calculated to be 217.5 kWh/kg TOC_{rem} for 80.6% TOC removal.

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