Journal of Water Resources and Geosciences
Vol. 4, No.1, 2025

The variations of PH and conductivity with time during the electrocoagulation process

Naseer A. Al Haboubi [1*], Shahad F. ALRubaye[1], Hussein A. Al-Amili[2]

[1]Chemical Department/ Engineering College/Al NahrainUniversity /Baghdad, Iraq
[2]Automated Manufacturing Engineering/Al-Khawarizmi College of Engineering/University of Baghdad/Baghdad, Iraq
*Corresponding Author's E-mail: naseer.a.alhaboubi@nahrainuniv.edu.iq

Abstract

This study represents the performance of an electrocoagulation process employing a clear plastic reactor with holes in the aluminum plate electrodes to allow water to pass between the plates in a totoidal pattern. Regarding the efficiency of the process, the most important factors that affect the electrocoagulation process (EC) are electrical conductivity and pH. Continuous flow was carried out to evaluate the effects of different parameters on the pH, and conductivity variations. Two types of water are used in this study to investigate the use of electrocoagulation (EC): river water and discarded reverse osmosis system water. Using bipolar and monopolar aluminum electrodes, the factors that were examined were the flow rate (600, 1000 L/h) and the number of electrodes (2, 4). The pH showed oscillations throughout the various experimental circumstances for concentrated water, while for river water, the variation of pH and conductivity was stable. As for pH values, for river water, the pH increases and conductivity decreases for all experiments except for the 600L/h flow rate with reversing polarity experiment and employing two plates where the pH decreases and conductivity increases. For concentrated water, it is obvious through the experiments that the variation of pH and conductivity show unstable responses like that results from using river water because of the higher conductivity of the solution which leads to higher chemical reactions to occur during the experiments.

Keywords: Aluminum, Electrocoagulation, pH, conductivity, reverse osmosis rejected water, river water.

Journal of Water Resources and Geosciences
Vol. 4, No.1, 2025

تغيرات درجة الحموضة (pH) والموصلية مع الزمن خلال عملية التجلط الكهربائي

نصير عبود الحبوبي[1,*]، شهد فاضل عبد[1]، حسين علي العاملي[2]

[1] قسم الهندسة الكيمياوية، كلية الهندسة، جامعة النهرين، بغداد، العراق.

[2]قسم هندسة التصنيع المؤتمت، كلية الهندسة الخوارزمي، جامعة بغداد، بغداد,العراق.

*البريد الالكتروني للمؤلف المراسل: naseer.a.alhaboubi@nahrainuniv.edu.iq

الخلاصة

تمثل هذه الدراسة أداء عملية التخثر الكهربائي باستخدام مفاعل بلاستيكي شفاف مع استعمال الأقطاب المصنوعة من الألمنيوم والتي تحتوي على ثقوب لجعل جريان المياه يكون بنمط متعرج بين الألواح. فيما يتعلق بكفاءة العملية، فإن العوامل الأكثر أهمية التي تؤثر على عملية التخثر الكهربائي (EC) هي الموصلية الكهربائية ودرجة الحموضة (pH) .تم تنفيذ تجارب ذات جريان مستمر لتقييم تأثيرات العوامل المختلفة على التغيرات في درجة الحموضة (pH) والموصلية. تم استخدام نوعين من المياه في هذه الدراسة واجراءعملية التخثر الكهربائي (EC) مياه الأنهار والمياه المرفوضة من عملية التناضح العكسي . باستخدام أقطاب الألمنيوم ثنائية القطب واحادية القطب، تم استخدام العوامل التالية: معدل التدفق (600، 1000 لتر/ساعة) وعدد الأقطاب (2، 4). أظهرت درجة الحموضة تقلبات في مختلف الظروف التجريبية للمياه المرفوضة من عملية التناضح العكسي، بينما بالنسبة لمياه الأنهار، كانت تغيرات درجة الحموضة والموصلية مستقرة. أما بالنسبة لقيم درجة الحموضة، فقد ارتفعت درجة الحموضة في مياه الأنهار وانخفضت الموصلية في جميع التجارب باستثناء تجربة تدفق 600 لتر/ساعة مع تغيير القطب واستخدام لوحين حيث تنخفض درجة الحموضة وتزيد الموصلية. بالنسبة للمياه المرفوضة من منظومة التناضح العكسي، من الواضح من خلال التجارب أن تغيرات درجة الحموضة والموصلية تظهر استجابات غير مستقرة كما هو الحال عند استخدام مياه الأنهار بسبب الموصلية الأعلى للمحلول مما يؤدي إلى حدوث تفاعلات كيميائية أكبر خلال التجارب.

الكلمات المفتاحية: الالمنيوم، التخثير الكهربائي، مقياس الحموضة، التوصيلية الكهربائية، المياه المرفوضة من عملية التناضح العكسي، مياه النهر.

1. Introduction

One of the most significant issues facing humanity today is ensuring that the majority of the world's population has access to clean water. The demand for clean water is particularly urgent in third-world nations. Rivers, canals, waterways, and other bodies of water are continually contaminated by the discharge of industrial effluents as well as by other human activities and natural processes. Clean water is necessary for human consumption, cooking, and personal hygiene.

Chemicals are now used to treat water. To finish the process, coagulants such as poly aluminum chloride (PAC) and alum $Al_2(SO_4)_3$ are used. These two approaches were chosen because of their straightforward treatment and procedure. However, because of its efficacy and friendly to the environment, some people choose electrocoagulation instead of utilizing particular chemicals and the resultant pollutant burden. Compared to traditional coagulation, electrocoagulation offers some economic benefits, such as reduced investment, maintenance costs, and energy efficiency. Additionally, electrocoagulation produces little sludge, has considerable and steady floc quality, produces good deposition, uses no hazardous chemicals, is simple to operate, and has a suitable pH range (Nugraheni et al., 2023).

The principles of flocculation treatment and coagulation are the foundation of electrocoagulation, an electrically operated coagulation procedure. Trivalent chemical coagulants, such as iron (Fe) salts or alum (aluminum (Al) salts), are frequently employed in coagulation and flocculation to neutralize particles and promote floc formation. Instead, the metal plates that make up the electrodes in electrocoagulation supply the metal ions, (Perren et al., 2018). Furthermore, because the sacrificial anodes oxidize fast, the essential anode and cathode electrodes are made of inexpensive metals like Al or Fe. Electrodes and an electrolytic cell are usually found in an electrocoagulation reactor (Senathirajah et al., 2023).

Compared to those utilized as coagulants, the metal hydroxides generated via EC have a greater capacity for adsorption on mineral surfaces. Because the coagulated particles created by this process are large, stable, and contain little bound water, filtering can readily remove them. Their effluent capacity may be appropriately set, and their criteria are straightforward. The primary reagents generated from the sacrificial anode are electrons. It greatly lowers the amount of sludge produced because it lacks the need for the addition of chemicals or reagents. Additionally, this technology can eliminate the hazardous compounds that were coagulants in the conventional effluent treatment processes (Moneer et al., 2022). Chemical treatment methods, while commonly used for water purification, have certain limitations that make them less ideal in some situations. One major drawback is the potential production of secondary pollutants. For example, chemicals used in water treatment may react with contaminants to create new, often harmful byproducts that further complicate the purification process. Additionally, chemical treatments can be costly due to the need for specialized chemicals and disposal of residual waste, making them less economically viable for large-scale or long-term applications.

In contrast, alternative methods like electrocoagulation offer significant advantages. Electrocoagulation uses electrical currents to destabilize and remove contaminants from water without the need for chemical additives. This approach can minimize the creation of secondary pollutants and is generally more cost-effective in the long run. Furthermore, it can be particularly effective for removing a wide range of pollutants, including heavy metals, oils, and other organic materials, making it a promising alternative to traditional chemical treatment methods.

A water treatment technique called electrocoagulation uses an electrochemical method to treat water from various sources or water that has been polluted. Although their methods are distinct, electrocoagulation and chemical coagulation both similarly remove contaminants. In the process of electrocoagulation, Al^{3+} is liberated from the electrode (anode) and creates an Al(OH) floc that may bind impurities and waterborne particles. A metal ion active coagulant (often aluminum or iron) is released into the solution at the anode, while hydrogen gas is generated as a result of an electrolytic reaction at the cathode. By utilizing a direct current to create ions from the anode that decay chemically, electrocoagulation removes impurities. The anode will release metal ions, H_2 gas, and OH as a result of the DC current flowing through it. Ion The method of electrocoagulation involves delivering an electric current into an aqueous media to destabilize pollutants that are suspended, emulsified, or dissolved therein. In its simplest form, an electrocoagulation reactor consists of an electrolytic cell with a single anode and a single cathode. The "sacrificial electrodes," which are conductive metal plates, may be made of the same material or a different substance (anode and cathode). The anode dissolves when an electric current is applied, producing metal cations as a consequence. Then, these cations spontaneously form polymeric metal hydroxide species in solution, similar to coagulant salts like alum and ferric chloride in conventional chemical coagulation.

Negatively charged particles may be neutralized by these cations and other charged polymeric metal hydroxide forms. The particles may combine to form aggregates or flocs after being neutralized, which will remove the pollutants. In addition to coagulation, flocculation, and settling, electro flotation also occurs during electrocoagulation. Electro flotation, which removes extra pollutants not eliminated in CC, happens as a consequence of the production of gas bubbles at both electrodes.

With soluble anodes, often aluminum or iron electrodes, electrocoagulation is an electrolytic process. The anode dissolution in electrocoagulation produces ions and hydroxides, which are well-known coagulants used in a flocculation process. The solution's pH has a considerable influence. On the stability of the hydroxides that are produced. The treatment of wastewater by electrocoagulation is well-recognized (Li et al. ,2008).

Water may contain various pollutants, including textile , mining products and pharmaceutical substances, which can negatively impact agricultural production. It is important to note that electrocoagulation presents an environmentally and economically viable alternative to traditional treatment methods. This technique is particularly beneficial in the treatment of industrial and agricultural waters, offering a more sustainable solution by reducing the reliance on harmful chemicals and minimizing waste. Its efficiency in removing a broad spectrum of contaminants makes it an attractive option for these sectors, where water quality management is crucial for both environmental protection and cost-effectiveness.

In this study, a brief recording for two parameters (pH and conductivity) was monitored during the electrocoagulation process for two types of water (Tigris River, Reverse osmosis rejected water) employing two and four electrodes. the electrocoagulation process was continuous using 600 and 1000 L/h flow rates.

2. Experimental work:

Electrocoagulation experiments were conducted in a continuous reactor setting using a 200 L electrochemical cell. Plates of aluminum were used as electrodes for the anode and cathode. Two and four electrodes were used, and two flow rates were studied (1000 and 600 L/h). The plates are made consisting of holes that are 2.5 cm in diameter and 5 cm apart. Figure 1 shows the schematic of the process. Figure 2 represents the electrodes used.

The effects of electrode surface area were taken into account with two and four electrodes. In the experiment with four plates, the distance between the first and second plates is 10 cm and identically is true between the third and fourth plates. In the experiment with two plates, the space between the plates is 40 cm. with 20 centimeters separating the second and third plates. Both bipolar and monopolar parallel connection types were used to link the plates. The anode and cathode both have a surface area of 2500 cm^2 (0.25 m^2). the first electrode is connected to the anode and the last electrode is connected to the cathode. The anode and cathode plates were connected to a DC power supply's positive and negative terminal (model: S-480-48, DC output: 48V- 10A). The applied voltage and current were 36 V and 3 A respectively.

Two water samples were used in this research, Tigris River, and rejected water from the reverse osmosis system. Table 1 shows the properties of each sample of water.

The electrodes were scraped with fine sandpaper before each experiment, washed for five minutes with a solution of 5% hydrochloric acid, rinsed with distilled water, and dried. Long-term operation of the electrodes is prevented from material precipitating on them by the cleaning procedure, which also has the passivating effect of reducing treatment efficacy and raising power needs. Thus, to get rid of and stop passivation insulation from developing, the electrodes were cleaned.

The need for cleaning for preventing interactions with accumulated deposits that can negatively impact system efficiency. Over time, contaminants such as scale, or biofilms can accumulate within treatment systems electrodes. These deposits can interfere with the proper functioning of the system by obstructing flow, reducing surface area for chemical or physical reactions, or creating conditions that promote the formation of secondary pollutants. Regular cleaning helps to maintain optimal performance, ensuring that the system operates at its highest efficiency, prevents equipment damage, and extends the lifespan of the treatment infrastructure. Additionally, cleaning helps to minimize the risk of contamination re-entering the treated water, ensuring the quality and safety of the final output.

Table(1): properties of types of water used in each run.

Runs	**Water type**	**Flow L/h**	**Polarity reversing**	**Number of plates**	**Conductivity** as µS/cm	**SO_4**	**Fe**	**Al**	**NTU**	**TH**	**ALK**
1	Conc.	1000	RP	2	4369	810	0.036	0.01	3.4	190	160
2	Conc.	1000	DP	2	3309	710	0.4	0.12	1.21	180	430
3	Conc.	1000	RP	4	4371	840	0.04	0.01	3.8	600	120
4	Conc.	1000	DP	4	3475	770	0.022	0.09	2.6	260	420
5	Conc.	600	RP	2	4305	770	0.01	0.09	3.5	190	430
6	Conc.	600	DP	2	4062	850	0.3	0.11	0.82	190	440
7	Conc.	600	RP	4	4287	810	0.09	0.02	2.5	750	390
8	Conc.	600	DP	4	6904.2	770	0.19	0.12	5.1	250	400
9	River	1000	RP	2	992	120	0.05	0.15	7.5	600	150
10	River	1000	DP	2	1039	200	0.169	0.11	1.12	110	380
11	River	1000	RP	4	998	190	0.09	0.12	1.14	400	140
12	River	1000	DP	4	932.4	240	0.027	0.11	2.22	850	443
13	River	600	RP	2	1423	300	0.03	0.1	0.24	800	290
14	River	600	DP	2	890.3	210	0.34	0.035	0.41	150	460
15	River	600	RP	4	1151	200	0.29	0.08	5.84	850	140
16	River	600	DP	4	1009	280	0.46	0.02	4.66	650	140

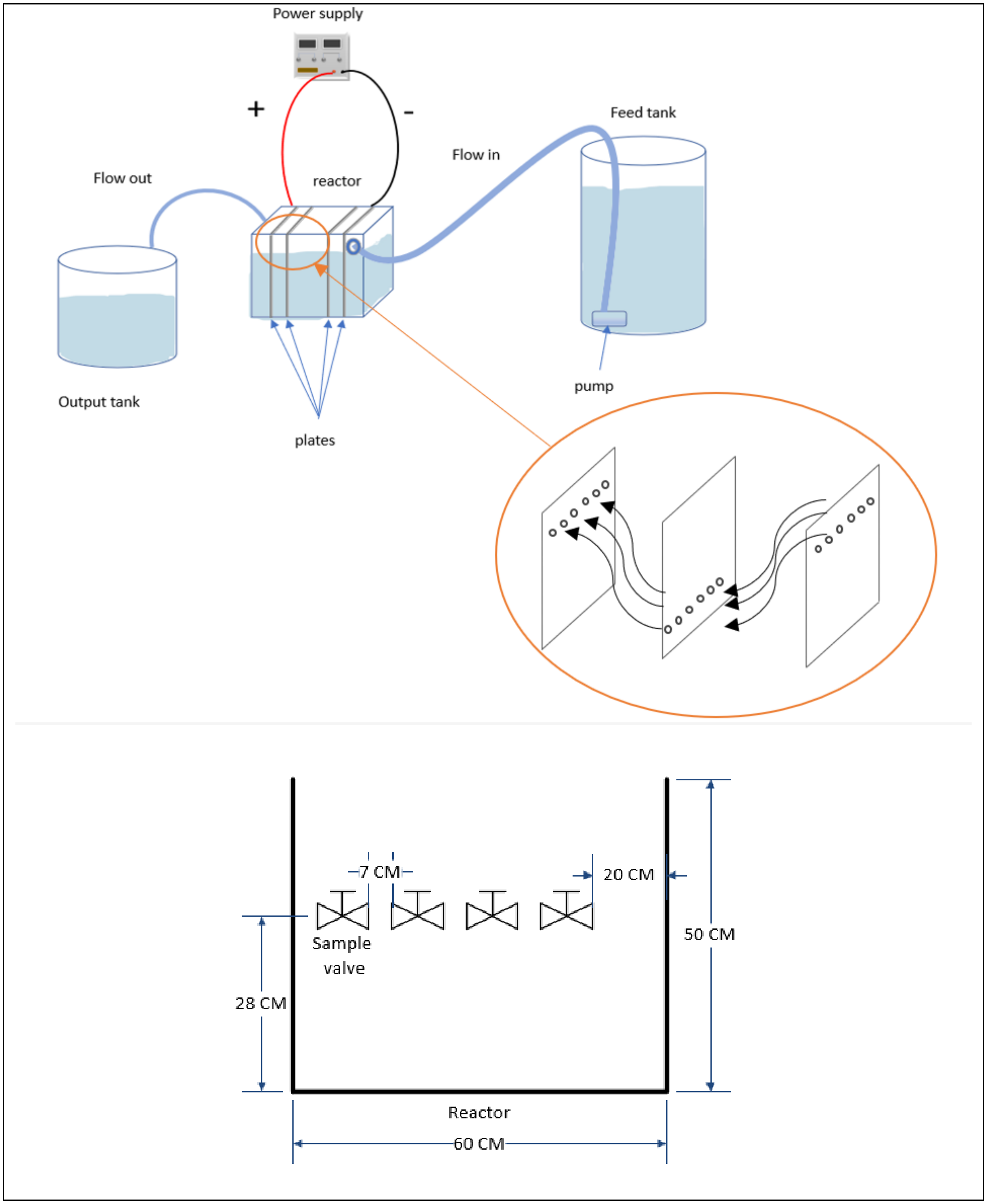

Figure (1): Schematic of reactor.

Figure (2): plates electrodes.

The pH and conductivity were recorded using LabVIEW.

The circuit consists of three transformers, a relay, a microcontroller (mega), a voltage sensor, a conductivity sensor, a pH sensor, a turbidity sensor, and a timer. The circuit connections are presented in Figure (3). Power supplies used are collected in Table (2). Figure (4) illustrates the diagram of the LabVIEW, and Figure (5) shows the front panel of the LabVIEW.

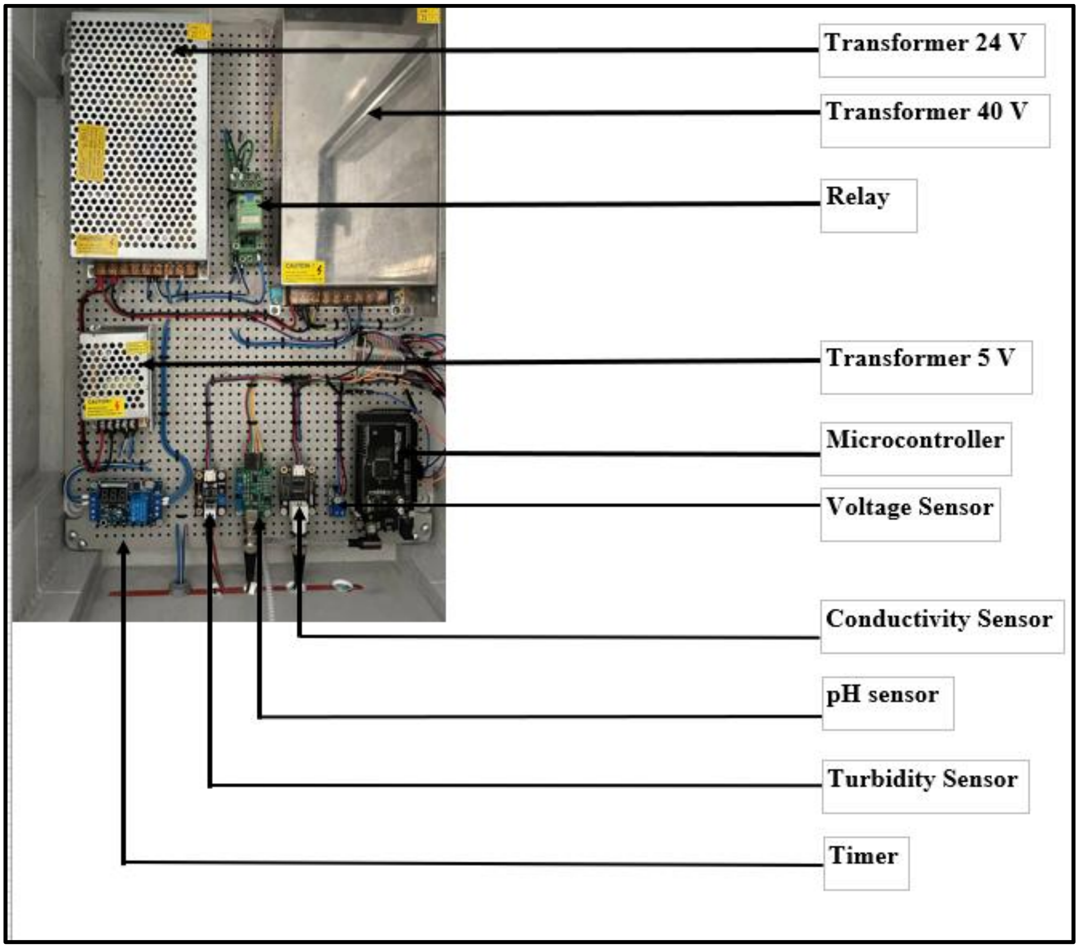

Figure (3): LabVIEW circuit design.

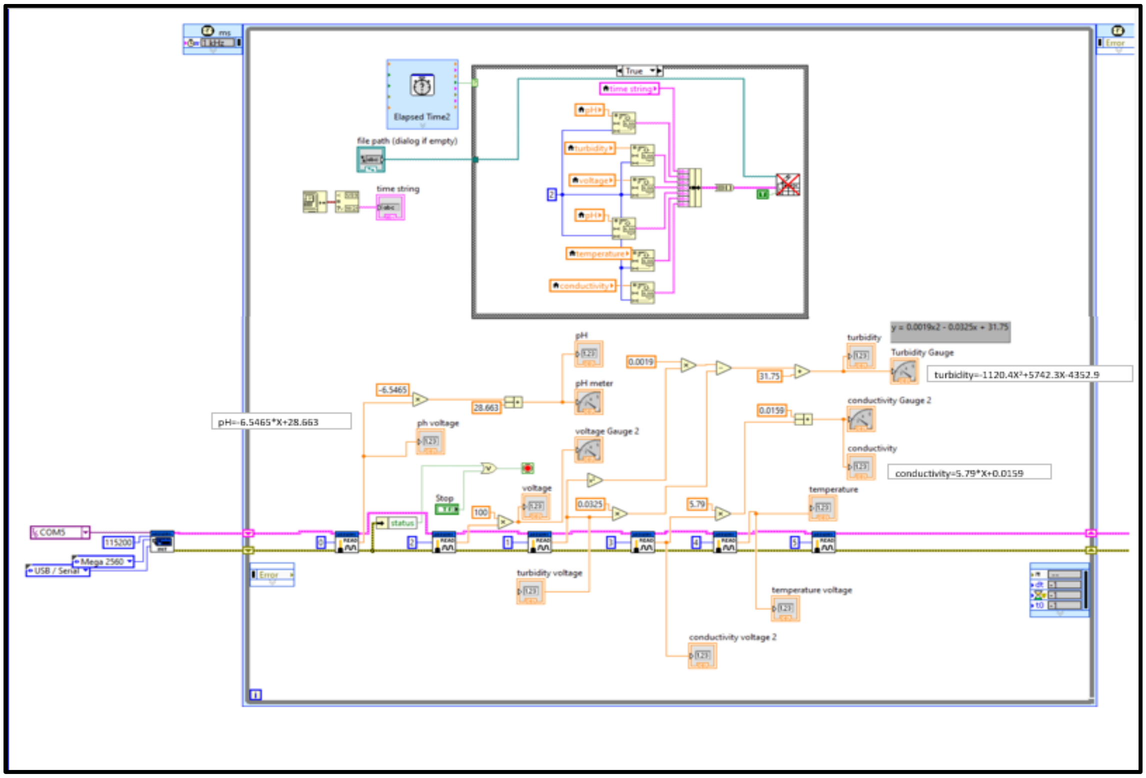

Figure (4): LabVIEW diagram.

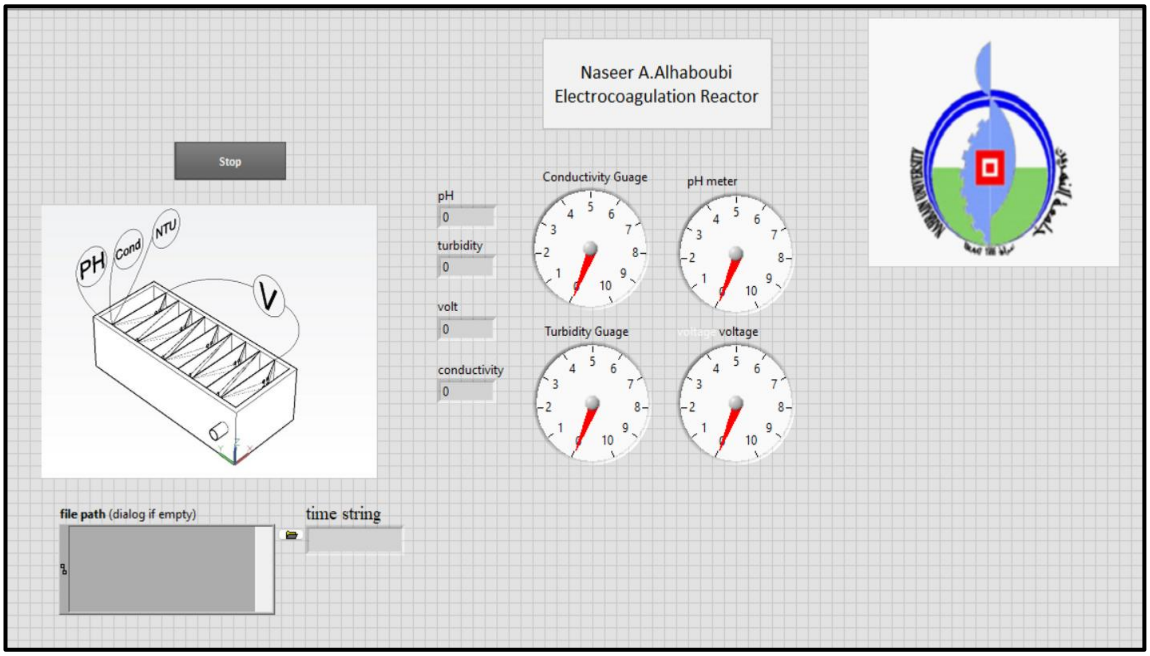
Naseer A.Alhaboubi
Electrocoagulation Reactor

Figure (5): LabVIEW front panel.

Table (2): Power supplies specifications.

Power Supply S-15-5	
AC input:	AC110/220+/-16%V
DC Output:	5V 3A
Power supply S-480-24	
Input voltage:	AC110/220+/-16% V
DC Output:	24 V 20A
Power supply S-480-48	
Input voltage:	AC110/220+/-15%V
DC Output:	48 V 10 A

3. Results and discussion:

It is well noticed that there is an apparent fluctuation of conductivity and pH over time for concentrated water treatment and river water treating process; in others, there was a significant increase, for concentrated and river water treating processes. Figures 6 to 11 show the conductivity variations and pH versus time for concentrated and river water. The same is evident for pH variations. This can be attributed to:

- It can be confirmed that the pH of the solution becomes more acidic or alkaline depending on the idea that it is known that in the vicinity of the anode, water electrolysis produces protons (H^+), which cause the area to become acidic. Also, it is known that this action lowers the pH near the anode, creating a more acidic environment. This means that the equilibrium between the generation of hydroxide ions at the cathode and the production of protons at the anode, as well as the solution's buffering ability, determines how the pH fluctuates inside the reactor. In other words, the ability of a material or solution to retain its pH after being treated with an acid or base is known as buffering capability. This suggests that higher-conductive solutions would be less vulnerable to acidic or basic solutions causing pH shifts.
- Conductivity can also influence pH variations near the electrodes in some electrochemical processes, such as electrolysis. For example, water electrolysis during electrocoagulation

results in protons at the anode and hydroxide ions at the cathode, which alter the pH surrounding the electrodes.

- A solution's ionic composition, which can contain both basic and acidic ions, influences its electrical conductivity. Variations in these ions' quantities can alter pH through chemical processes that produce or absorb hydroxide ions (OH^-) or protons (H^+). For example, carbonate ions (CO_2^{3-}) in water can mitigate pH fluctuations because they combine with protons to form bicarbonate ions (HCO_3^{1-}).

Some suggested that the localized pH zones near the anode and cathode indicate sufficient solution mixing is critical to the EC system design to minimize these observed localized pH zones (Tampa Graduate Theses et al., 2022).

Due to its larger surface area, the bipolar connection may have a higher operating cost. A greater surface area than that of monopolar parallel in the electrocoagulation system with bipolar series preferentially the anodic oxidation. Due to the higher intensity of the bipolar connection compared to the other kind, the removal efficiency of the ions is similarly more elevated than that of the monopolar connection for the same amount of current density

Figure 6 depicts the conductivity variation with electrolysis time for the continuous process of treating river water. The conductivity of the solution increases by 3.73% as shown in figure 6 a for the river water treatment procedure, 3.91% as shown in figure 6 b, and 0.91% and 0.86% as shown in figure 6 c and d, respectively. The highest removal of conductivity was conducted by using four plates with a flow rate of 600 L/h, employing polarity reversing. Also, there was a well-noted increase in the pH for fig. 6 (a, b, c, and d). In figure 6 d, it is clear that there was a minor increase in the conductivity; this last increase is attributed to the formation of soluble species.

During the process, protons are consumed, which explains why conductivity declines and pH rises (Tchamango et al., 2010).

Figures (6) and (7) show a decrease in the conductivity, which are the same results as the studies of (Hakizimana et al., 2016) (Tchamango et al., 2010) (Franco et al., 2017) (Ahmed et al., 2012).

Also, close to the cathode: Water electrolysis produces hydrogen ions (OH^-) at the cathode. The atmosphere becomes more alkaline due to this process, which raises the pH level close to the cathode.

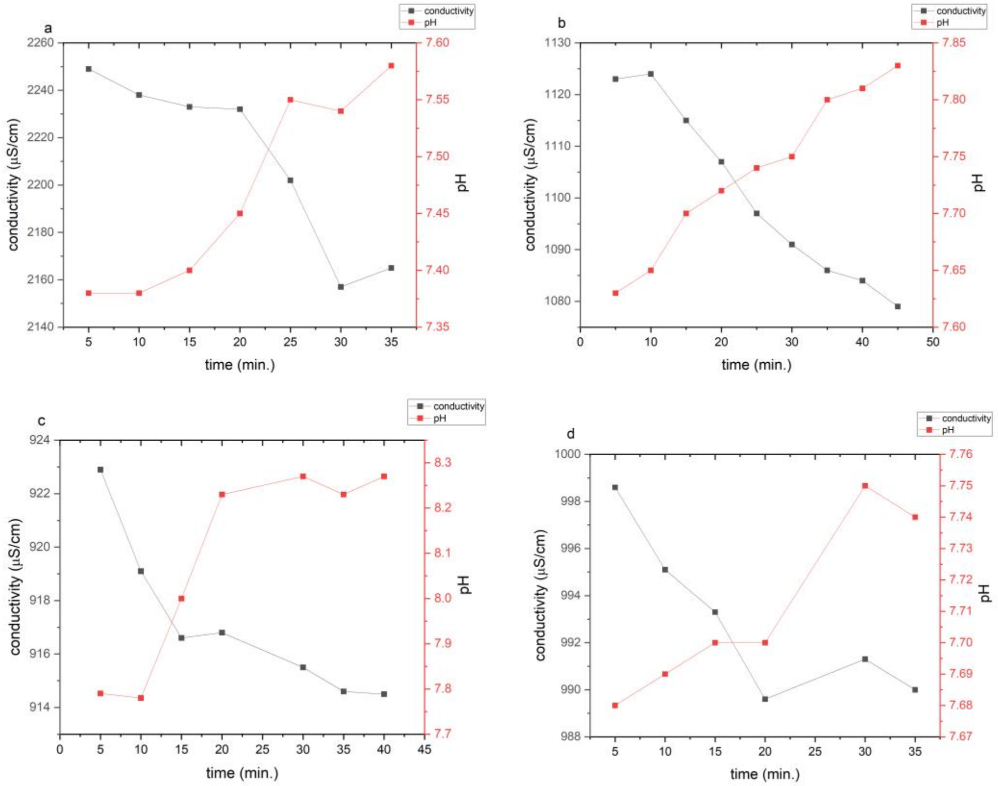

Figure (6): A river water continuous process. a. two plates, 600 L/h, absence of polarity reversal. b. four plates, 600 L/h, with polarity reversal. c. two plates, 1000 L/h, absence of polarity reversal. d. four plates, 1000 L/h with polarity reversing.

In figures (6) and (7), it can be shown that while the pH increases, the conductivity decreases.

This can be attributed to the fact that the treated water may have a higher pH than the untreated water if the hydroxide ions predominate during treatment.

The decrease in conductivity can be attributed to different reasons:

1. The reduction in the concentration of negative ions, which combine to Al^{3+}as in the equation below

$Al^{3+} + n\ Lig^{-} \rightarrow Al(Lig)n]^{(3-n)+}$

$Al(H_2O)_m^{3+}{}_{(aq)} + n\,Lig^-{}_{(aq)} \rightarrow Al(H_2O)_{m-n}(Lig)_n]^{(3-n)+}{}_{(aq)} + nH_2O_{(aq)}$

or for the polymer formation, as mentioned in the equation

$nAl(OH)_3 \rightarrow Al_n(OH)_{3n}$

1 .The precipitation, as hydroxides, of the metallic species is the same as stated by the study of (Mouedhen et al., 2009).

2. A decrease in hardness species, such as calcium and sulfate compounds, reduced electrical conductivity; these findings align with the results obtained by (Mendez-Ruiz et al., 2023).

3. The precipitation of salts and the adsorption of anions and cations on the aluminum hydroxides account for the salinity drop, such as $CaCO_3$, $CaSO_4$, $MgCO_3$, and $MgSO_4$, The electrocoagulation process's elimination of saline appears to be the primary cause of the conductivity decline which is the same stated by the study of (Hakizimana et al., 2016).

4. For a fixed tension, the conductivity reduces slightly when the potential between the electrodes increases and then gradually increases over time. The primary causes of the decrease in conductivity are the formation of Al^{3+} complexes, polymerization of $Al(OH)_3$, adsorption of ions on aluminum hydroxide and its polymers, and the formation of low-mobility structures like $Al(OH)_4^{-1}$ and $Al(OH)_5^{-2}$ that formed an essential medium. Since the decrease in conductivity does not encourage ion transport, the formation of aluminum hydroxide, which adsorbs pollution agents, cannot perform its full function.

5. The decrease in conductivity could not explain the rates of physiochemical parameter reductions. These reductions were most likely caused by a chemical interaction at the cathode between hydroxide ions and metal due to water reduction, which is the same statement in the study of (Drogui et al., 2014).

6. Protons are consumed along with the electrolysis, which primarily gives the solution its conductivity. The overall reaction can be noticed that the protons are consumed throughout the process. This is confirmed by the study of (Tchamango et al., 2010).

For the concentrated water experiment using two plates, Figure (7)presents that the effluent conductivity did not vary during the first 15 min (4027 μS/cm), then it sharply decreased with time to reach 3727 μS/cm. The pH data represented in figure (7) forms almost a mirror image of the conductivity profile as it increases with time.

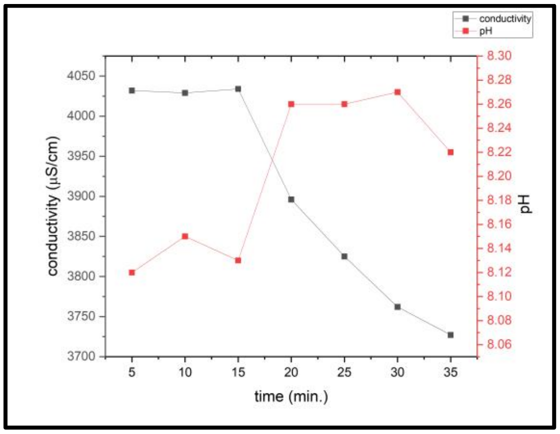

Figure (7): The continuous process of treating concentrated water with a flow rate of 600 L/h and the absence of polarity reversal employing two plates.

From the results of the river water continuous process with 600 L/h and employing polarity reversing, it is interesting to note in figure 8 that for the two plates experiment, the conductivity of the solution increased with time while the pH decreased after passing 15 minutes of the treatment.

The decrease in pH with the increase in conductivity can be seen in the Figures, and this is attributed to the fact that if the pH is low near the anode, the conductivity of the membrane or its surface may rise because unoxidized protons can travel more easily via the concentration of ions in the membrane.

The increase in the conductivity of the solution can be attributed to:

1.Higher conductance levels are typically the consequence of high ion concentrations, including both primary and acidic ions. Higher ionic strength solutions generally have more buffering capacity and are linked with increased conductivity.

2.Conductivity, or a solution's capacity to carry electric current, is determined by the concentration of dissolved ions in the solution. Higher concentrations of ions, which can include both acidic and alkali ions, are often responsible for higher conductance.

3.It's possible that the subsequent rise in conductivity was caused by the progressive production of soluble metal hydroxides, which is confirmed by the study of (Golder et al., 2005).

4.This can also be associated with the production of polymers, the adsorption of positive ions on the flocs of aluminum hydroxide or its polymers, and the decrease in the concentration of negative ions, which combine to produce Al^{3+}. The same result as an increased conductivity of the treated water is noted, which is the same result as the study of (Al-Qodah & Al-Shannag, 2017) (Al-Qodah & Al-Shannag, 2017).

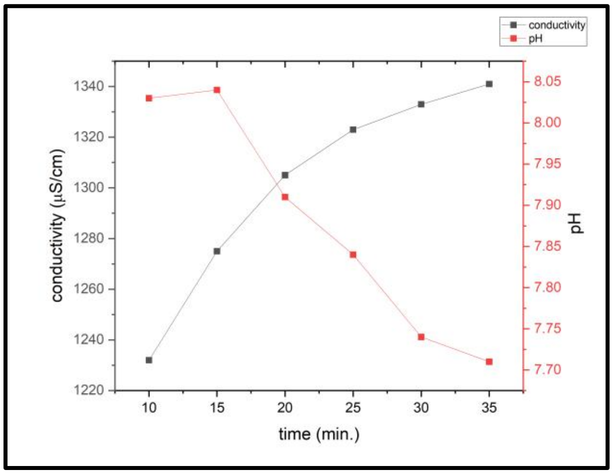

Figure (8): River water continuous process with 600 L/h flow rate with polarity reversal two plates.

For a continuous process of treating concentrated water without reversing the polarity. Based on the results obtained in figure 9 a and b, an increase in the conductivity is the same trend over time. It is also noted that those two runs have an equal initial sulfate content of 700 mg/l. For figure 9 c and d, the same increasing trend for the conductivity increase was also noted; the sulfate input values were 710 and 770 for c and d, respectively. In figure 9 b, it can be noticed that the pH trend almost mirrors the conductivity trend.

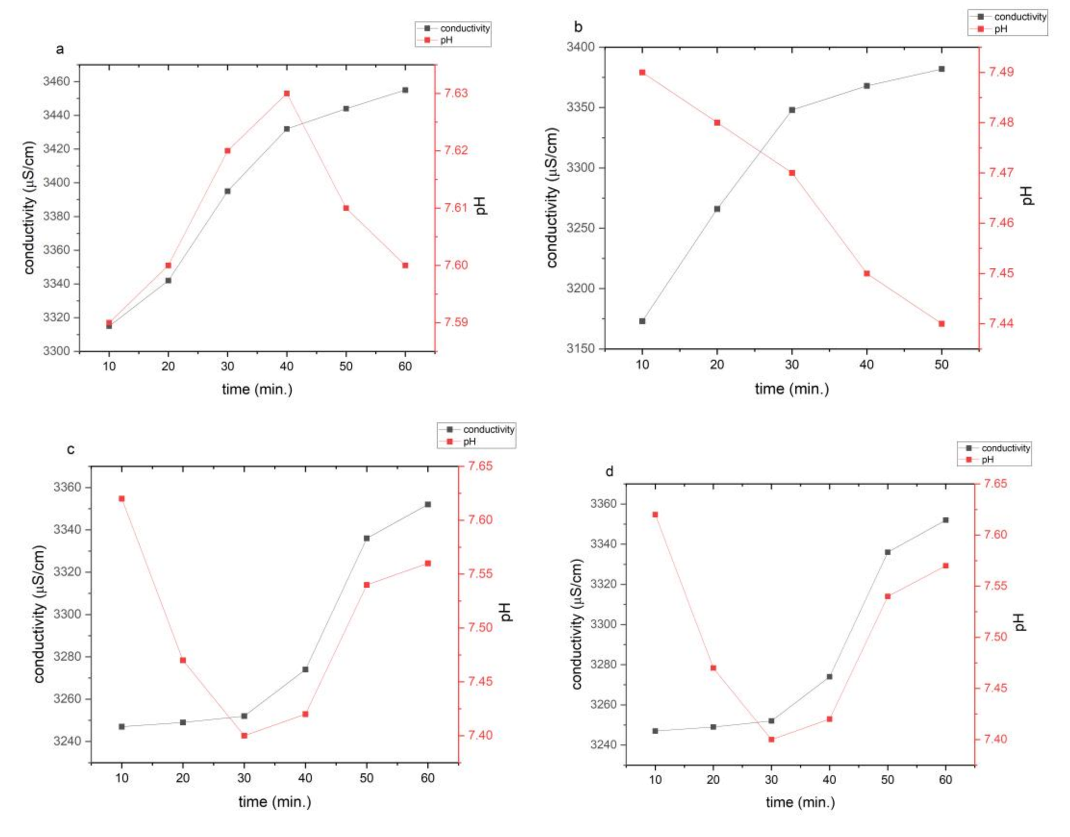

Figure (9): The continuous process with concentrated water and the absence of polarity reversal. a. two plates 600 L/h. b. four plates 600 L/h. c. two-plate 1000 L/h. d. four plates 1000 L/h.

In figure 10 a, it can be concluded that there is no noticeable change in the pH during the time with a well-noted decrease in the conductivity value. In figure 10 b, c, and d, conductivity makes a mirror for the pH data.

Figure (10) shows a fluctuating trend for pH values, as there was no significant change in the data representing the pH.

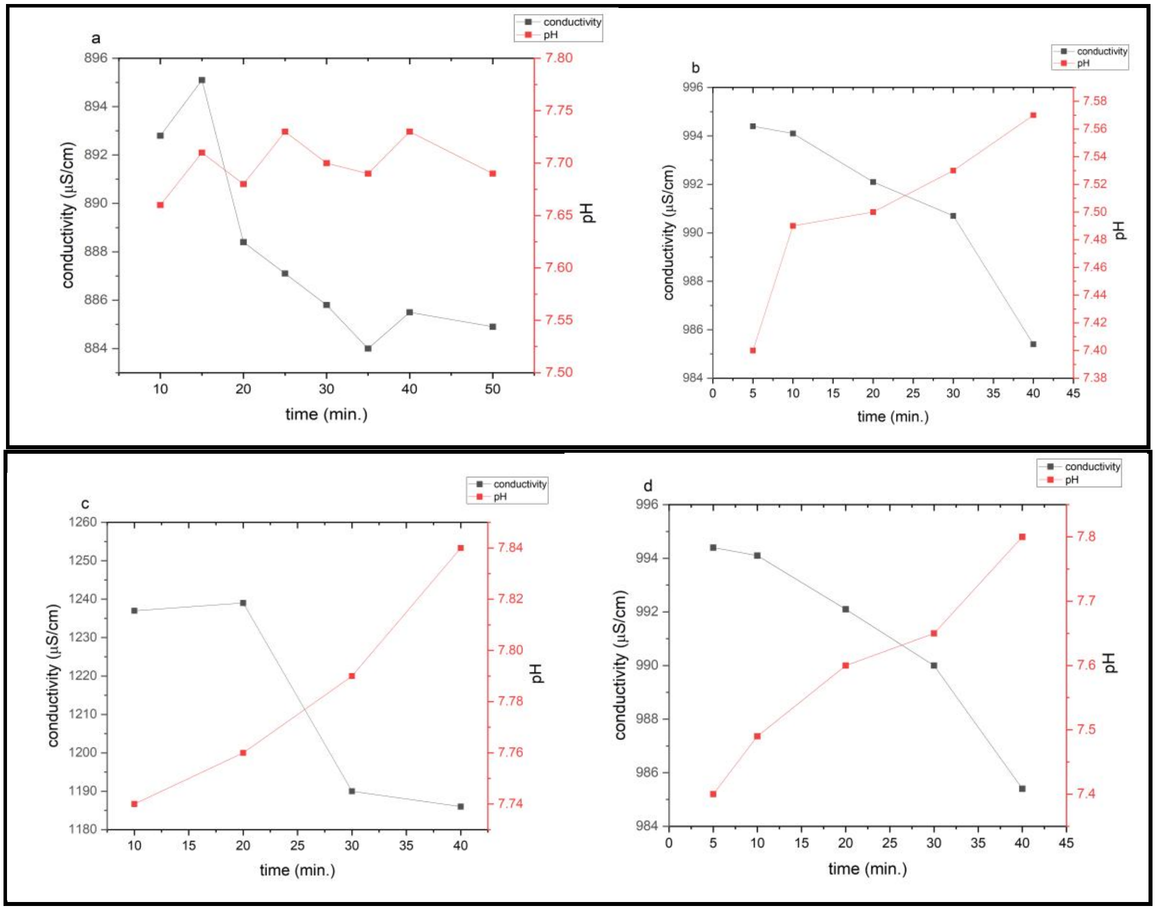

Figure (10): River water continuous process. a. two plates, 600 L/h, the absence of polarity reversal. b. four plates, 600 L/h, the absence of polarity reversal. c.1000 L/h and the absence of polarity reversal for the two plates. d. 1000 L/h with polarity reversing two plates.

For the concentrated water treatment with polarity reversing, the reported results in figure 11 a and c confirm that the conductivity decreased similarly for both flowrates 1000 and 600 L/h.

For figure 11 b, the conductivity gradually decreases in the first 20 min. Before it gradually increased again. This last rising attributed to the formation of soluble species.

For figure 11 c, it could be well noticed that the conductivity fluctuated in the same manner as seen in figure 11 a; this agreed well with the results presented in the literature which indicated that the conductivity of the solutions was not affected by the electrocoagulation (Gutiérrez-Bouzán & Buscio, 2018) (Hu et al., 2003) (Suryaningsih et al., 2021) (Vepsäläinen, n.d.). The solution conductivity did not vary during the experiments; only a slight decrease was noticeable (Mameri et al., n.d.). Since the water's conductivity was previously suitable for drinking water, the lack of a drop in conductivity is acceptable (Franco et al., 2017).

The data's fluctuation was apparent for the pH variations in figures 11 a and c; for figure 11 b, there was a noticeable decrease.

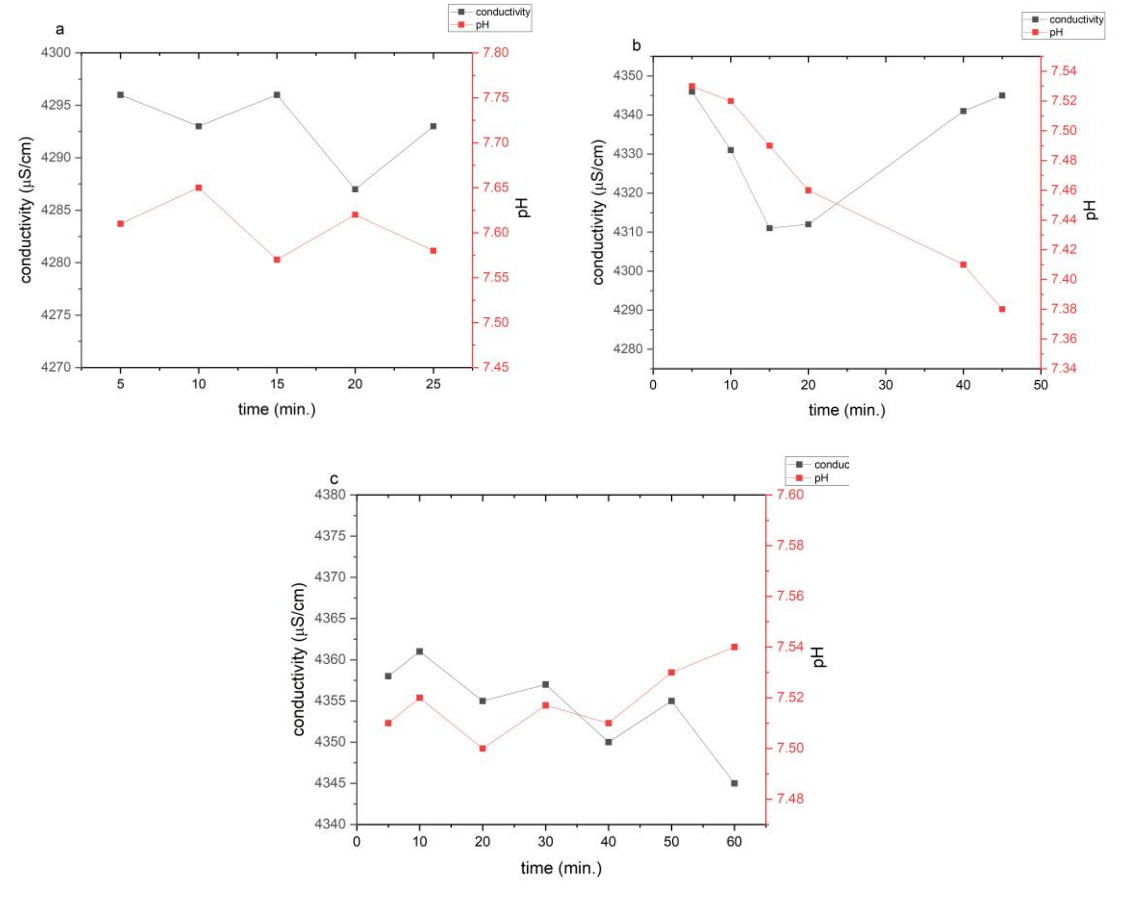

Figure (11): Concentrated water continuous process with polarity reversing. a. with 600 L/h two plates. b. 1000 L/h four plates. c. 1000 L/h two plates.

4. Conclusion:

Conductivity and pH have the most effects on the electrocoagulation process (EC) in terms of process efficiency. Tests of continuous flow were performed to assess the impact of various factors on pH and conductivity fluctuations. To explore the use of electrocoagulation (EC), two types of water are employed in this study: river water and water from abandoned reverse osmosis systems. Aluminum electrodes, both monopolar and bipolar, were used. The number of electrodes (2,4) and the flow rate (600,1000 L/h) were the variables that were looked at. For concentrated water, the pH fluctuated during the different testing conditions, while for river water, the pH and conductivity variations were stable. Regarding pH values, for river water, all tests show that conductivity increases and pH increases, except the 600 L/h flow rate with reversing polarity experiment and using two plates, where conductivity increases and pH declines. Because of the high conductivity of the solution, which causes more chemical reactions to occur throughout the experiments, it is clear from the studies that variations in pH and conductivity for concentrated water exhibit unstable behavior similar to what's observed when using river water.

References:

Ahmed, M. T., Chaabane, T., Maachi, R., & Darchen, A. (2012). Efficiency of a pretreatment by electrocoagulation with aluminum electrodes in a nanofiltration treatment of polluted water. *Procedia Engineering*, *33*, 465–474. https://doi.org/10.1016/j.proeng.2012.01.1226

Al-Qodah, Z., & Al-Shannag, M. (2017). Heavy metal ions removal from wastewater using electrocoagulation processes: A comprehensive review. In *Separation Science and Technology (Philadelphia)* (Vol. 52, Issue 17, pp. 2649–2676). Taylor and Francis Inc. https://doi.org/10.1080/01496395.2017.1373677

Drogui, P., Blais, J.-F., Lekhlif, B., Oudrhiri, L., Zidane, F., Drogui, P., & Blais, J. F. (2014). Study of the electrocoagulation of electroplating industry wastewaters charged by nickel (II) and chromium (VI). *J. Mater. Environ. Sci*, *5*(1), 111–120. https://www.researchgate.net/publication/279937813

Franco, D., Lee, J., Arbelaez, S., Cohen, N., & Kim, J. Y. (2017). Removal of phosphate from surface and wastewater via electrocoagulation. *Ecological Engineering*, *108*, 589–596. https://doi.org/10.1016/j.ecoleng.2017.07.031

Golder, A. K., Hridaya, N., Samanta, A. N., & Ray, S. (2005). Electrocoagulation of methylene blue and eosin yellowish using mild steel electrodes. *Journal of Hazardous Materials*, *127*(1–3), 134–140. https://doi.org/10.1016/j.jhazmat.2005.06.032

Gutiérrez-Bouzán, C., & Buscio, V. (2018). Combining electrochemistry and UV for the simultaneous wastewater decolorization and reduction of salinity. *AIMS Environmental Science*, *5*(2), 96–104. https://doi.org/10.3934/environsci.2018.2.96

Hakizimana, J. N., Gourich, B., Vial, C., Drogui, P., Oumani, A., Naja, J., & Hilali, L. (2016). Assessment of hardness, microorganism and organic matter removal from seawater by electrocoagulation as a pretreatment of desalination by reverse osmosis. *Desalination*, *393*, 90–101. https://doi.org/10.1016/j.desal.2015.12.025

Hu, C. Y., Lo, S. L., & Kuan, W. H. (2003). Effects of co-existing anions on fluoride removal in electrocoagulation (EC) process using aluminum electrodes. *Water Research*, *37*(18), 4513–4523. https://doi.org/10.1016/S0043-1354(03)00378-6

Mameri, N., Yeddou, A. R., Lounici, H., Belhocine, D., Grib, H., & Bariou, B. (n.d.). *DEFLUORIDATION OF SEPTENTRIONAL SAHARA WATER OF NORTH AFRICA BY ELECTROCOAGULATION PROCESS USING BIPOLAR ALUMINIUM ELECTRODES*.

Mendez-Ruiz, J. I., Medina-Toala, A. N., Gutierrez, L., & Valverde-Armas, P. E. (2023). Comparative evaluation of an advanced electrocoagulation treatment system versus a conventional lime softening treatment for removing Ca2+, SO42−, and Mn in groundwater. *Case Studies in Chemical and Environmental Engineering*, *8*, 100448. https://doi.org/10.1016/j.cscee.2023.100448

Moneer, A. A., El-Mallah, N. M., Ramadan, M. S., & Shaker, A. M. (2022). The effect of a novel electrode on the removal of Reactive Yellow 17 dye by Electrocoagulation technique. *Egyptian Journal of Aquatic Research*, *48*(3), 191–197. https://doi.org/10.1016/j.ejar.2022.04.002

Mouedhen, G., Feki, M., De Petris-Wery, M., & Ayedi, H. F. (2009). Electrochemical removal of Cr(VI) from aqueous media using iron and aluminum as electrode materials: Towards a better understanding of the involved phenomena. *Journal of Hazardous Materials*, *168*(2–3), 983–991. https://doi.org/10.1016/j.jhazmat.2009.02.117

Nugraheni, P. W., Maleiva, L. T. N., Ramadhan, F., Kusumawardhani, E., & Putra, L. S. A. (2023). Effectiveness of Well Water Treatment Method with Electrocoagulation, Coagulation, and Electrocoagulation-Coagulation Using Alum as Coagulant. *IOP Conference Series: Earth and Environmental Science*, *1228*(1), 012039. https://doi.org/10.1088/1755-1315/1228/1/012039

Perren, W., Wojtasik, A., & Cai, Q. (2018). Removal of Microbeads from Wastewater Using Electrocoagulation. *ACS Omega*, *3*(3), 3357–3364. https://doi.org/10.1021/acsomega.7b02037

Senathirajah, K., Kandaiah, R., Panneerselvan, L., Sathish, C. I., & Palanisami, T. (2023). Fate and transformation of microplastics due to electrocoagulation treatment: Impacts of polymer type and shape. *Environmental Pollution*, *334*. https://doi.org/10.1016/j.envpol.2023.122159

Suryaningsih, N., Widayatno, T., Sugiharto, A., & Fuadi, A. M. (2021). The Effectivity of Aluminum Electrode for River Water Purification Using Electrocoagulation. *IOP Conference Series: Materials Science and Engineering*, *1053*(1), 12130. https://doi.org/10.1088/1757-899x/1053/1/012130

Tampa Graduate Theses, U., USF Graduate Theses, D., Castro Carias, M., & Carias, C. (2022). Evaluation of Aluminum Dissolution, Current Density, and Pitting Evaluation of Aluminum Dissolution, Current Density, and Pitting Patterns During Electrocoagulation Patterns During Electrocoagulation.*Scholar Commons Citation Scholar Commons Citation "Evaluation of Aluminum Dissolution, Current Density, and Pitting Patterns During Electrocoagulation" (2022). USF Tampa Graduate Theses and Dissertations*.

Tchamango, S., Nanseu-Njiki, C. P., Ngameni, E., Hadjiev, D., & Darchen, A. (2010). Treatment of dairy effluents by electrocoagulation using aluminium electrodes. *Science of the Total Environment*, *408*(4), 947–952. https://doi.org/10.1016/j.scitotenv.2009.10.026

Vepsäläinen, M. (n.d.). Electrocoagulation in the treatment of industrial waters and wastewaters.