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EFFECT OF SPACING OF DIFFERENT TYPES OF ELECTRODES IN THE ELECTROCOAGULATION PROCESS

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Abstract:

Electrocoagulation technology is an executive method of using electrical power to rebound and flocculate pollutants without needing to add coagulations. This treatment process can remove small particles since the direct current is applied, and set them into motion. Also, electrocoagulation could decrease the remainder of waste production. This research concentrates on the use of electrocoagulation depending on a scaled open channel physical model using installed different types of electrodes such as Stainless Steel, Steel, and Aluminum to reduce the contaminants. The used electrodes have been installed parallel to the water flow direction in the stream, with a variation of four values of volts used in the experiment with the different spacing between electrodes 1cm, 2cm. The selected inflow water is Q=10 l/hr for the physical model has quality indicators limits such as COD, BOD, Total Coliform, and Fecal Coliform. The outcomes of the paper present that the best removal efficiencies depend on electro-coagulation by using Stainless Steel sheets and the spacing between these sheets equal 2cm, this distance reduces the current density Which leads to reducing the cost, also the water produced is suitable for agricultural and industrial use.

Keywords: Electrocoagulation; Stainless Steel electrodes; Water treatment; Aluminum electrodes

تأثير التباعد بين الاقطاب الكهربائية المختلفة فى التختير الكهربي

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الملخص

تقنية التختير الكهربي هي عملية معالجة المياه من الملوثات وتلبدها باستخدام تيار كهربائي دون الحاجة إلى إضافة مادة التختير . التختر الكهربى يحدث مع وجود التيار الكهربى ، وهو قادر على إزالة الجزيئات الصغيرة منذ تطبيق التيار المباشر ، وتحريكها. أيضًا ، يمكن أن يقلل التختير الكهربي من بقايا إنتاج النفايات. يركز هذا البحث على استخدام التختر الكهربائي اعتمادًا على نموذج فيزيائي لقناة مفتوحة باستخدام أنواع مختلفة من الأقطاب الكهربائية المثبتة مثل الفولاذ المقاوم للصدأ والحديد والألومنيوم لتقليل تركيز ملوثات المياه ، وقد تم تركيب الأقطاب الكهربائية المستخدمة بالتوازي مع اتجاه تدفق المياه مع اربع قيم مختلفة من الفولتات المستخدمة في التجربة مع تباعد مختلف بين الأقطاب ١ سم ، ٢ سم. المياه المتدفقة المختارة معدل التدفق= 10 لتر / ساعة ومن خلال التجربة يتم تقييم بعض المؤشرات الخاصة بجودة المياه مثل COD، BOD ، إجمالي القولونيات ، والقولونيات البرازية. أظهرت النتائج أن معدل تدفق الماء البالغ ١٠ لتر / ساعة هو الأفضل لهذا التطبيق باستخدام أقطاب الفولاذ المقاوم للصدأ والمسافة بين الأقطاب الكهربائية ٢ سم ، هذه المسافة تقلل من كثافة التيار مما يؤدي إلى تقليل التكلفة وفي نفس الوقت تكون المياه المنتجة مناسبة للاستخدام الزراعي والصناعي

الكلمات المفتاحية: التختير الكهربي. أقطاب الفولاذ المقاوم للصدأ. معالجة المياه . أقطاب الالومنيوم

1. Introduction

The recycling of wastewater has come to be essential. Required industrial and national wastewater to sidestep environmental contamination and especially pollution of clean water incomes are suitable for national and international problems. Wastewater that used as an additional source of irrigation and is unavoidable for increased agricultural production [1]. Wastewater treatment is a promising practice that helps in reducing the pollution of the environment exposed to pollution through the removal of sewage water in the surface or groundwater. Treated sewage water has some benefits above other sources of water, it decreases contamination, increases groundwater incomes by artificial restoration and it has a good nutrient basis for landscape and farm irrigation [1]. Other technologies have been described for the behavior of water and wastewater for example nanotechnology [2] Photocatalytic [3], Advanced Oxidation Processes [4], and Solar Energy [5]. In the previous years, there was a growing interest in the advance of environmental-friend electrochemical systems to treat water. Electro-coagulation (EC) is one of the unusual techniques for wastewater treatment. The Electro-coagulation process enjoys a lot of advantages for example stress-free operation, little treatment time, no chemical requirement, and low sludge production [6, 7].

A literature review illustrates that electro-coagulation is an effective behavior method for dissimilar wastes, such as textile industries, soluble oils, liquid of food, aquaculture wastewater, sewages from paper production, textile wastewater, polymer., and herbicide. Working on this paper for the EC process. The EC has been proposed as an advanced way of contaminant elimination from wastewaters to develop the discharge quality before wastewater reuse for agriculture purposes. This study is essentially motivated by the ability of EC tools to develop wastewater quality by removal of BOD, COD, Total Coliform, and Fecal Coliform under different operative conditions. The Electrocoagulation concept diagram is shown in Figure 1.

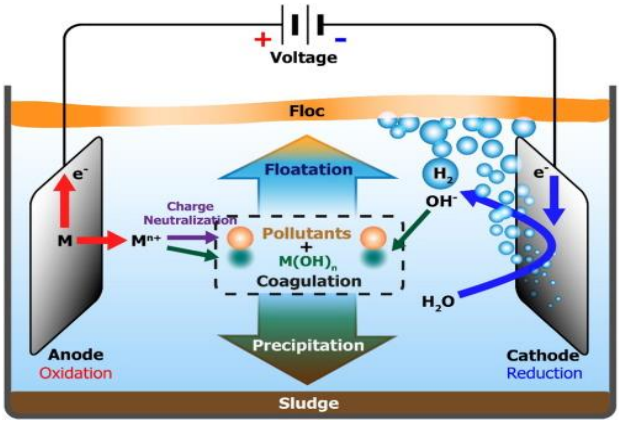


Fig.1. Electrocoagulation Concept. [8]

2. Experiment

In this research, the study of a newly designed Electro-coagulation (EC) reactor to domestic and sewage water in a stream of an open channel physical model (prototype)is tested. The reactor puts electrodes in parallel with the direction of water flow and studies the effect of spacing between electrodes 1cm, 2cm and study the effect of this on the quality of water in accord with different input electric power values of the reactor and fix the flow discharge 10 L/hr and use different types of Electrodes Stainless Steel, Iron, Aluminum.

2.1 Equipment of Experiment

Electro-coagulation exams in this effort, dissimilar Sheet kinds were used for example stainless steel (SS), iron (Fe), and aluminum (Al) Sheets. The whole active sheets area and the spacing between sheets, sheets kind, sheet mass, pH, current strength, and time were used as various issues that might affect the contaminant's efficiencies of removal. At the end of each case, Sheets of metal were cleaned carefully with water to eliminate any solid waste remainders on the faces and dried, except with iron electrodes we submerged electrodes before using them in 10 % HCl solution, the volume of the wastewater sample was 40 L. Aluminum (AL), iron (Fe) and stainless-steel (SS) sheets with measurements of (57cm× 10cm × 2mm) were used as electrodes. The number of electrodes is 4 sheets. started at time zero (t=0) and it was the starting time of the EC method. This case takes about 3.5 hours, the samples were withdrawn, filtered with filter paper (0.45 μm), and analyzed

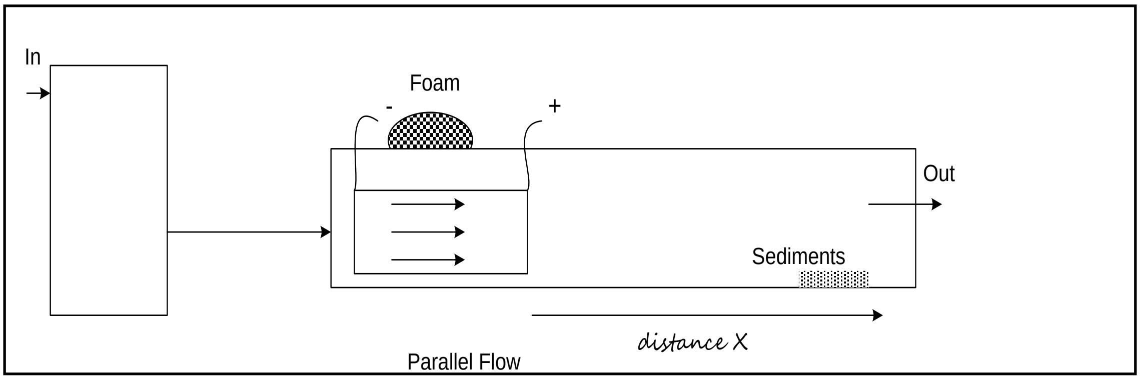


Fig.2. Cross-section of the Experiment

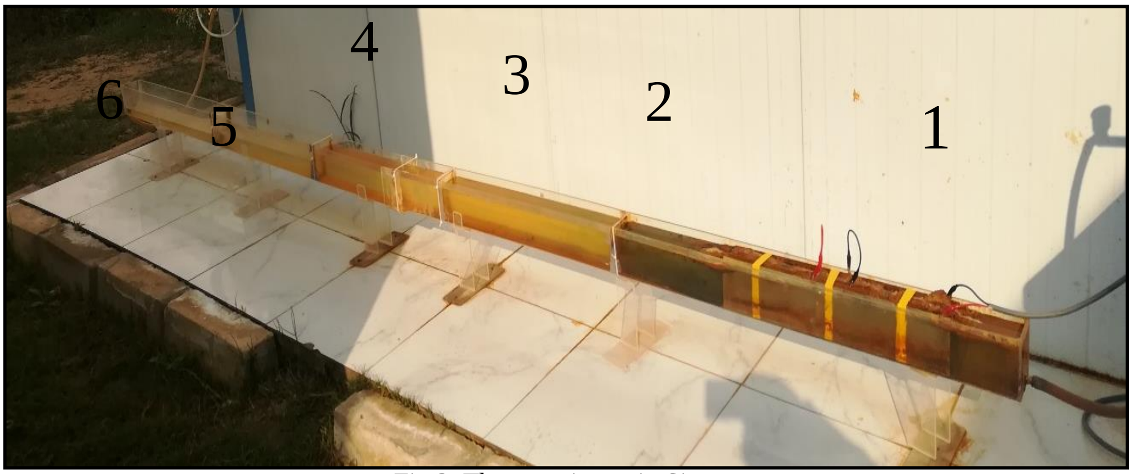
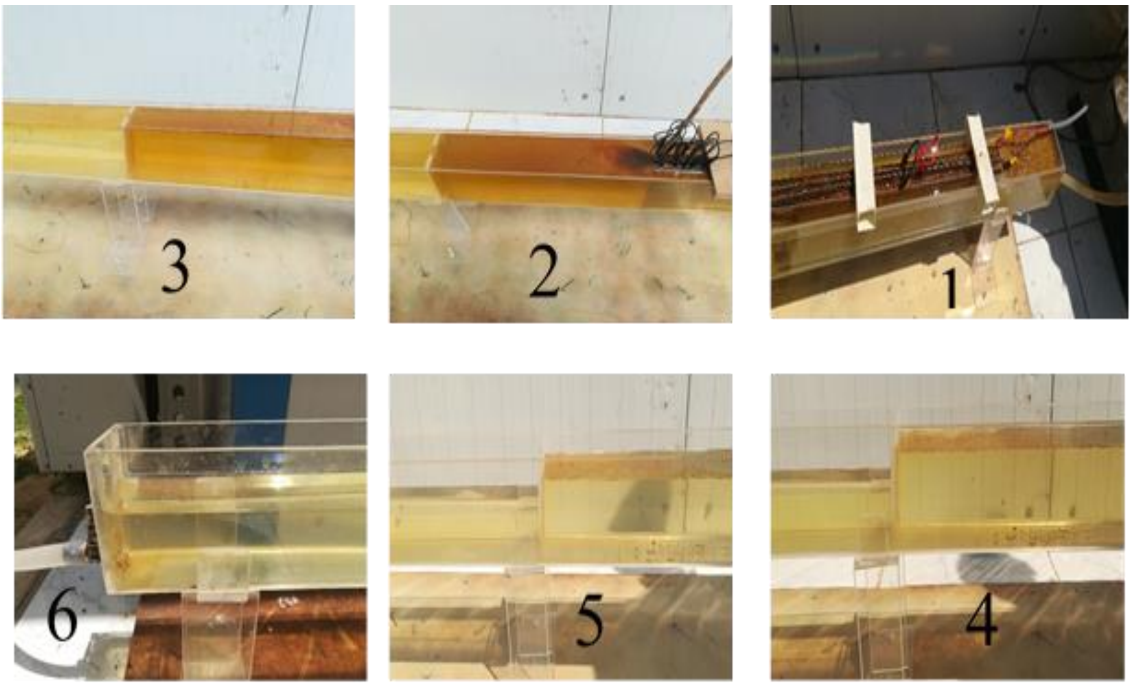


Fig.3. The experiment in Situ.



3. Methodology

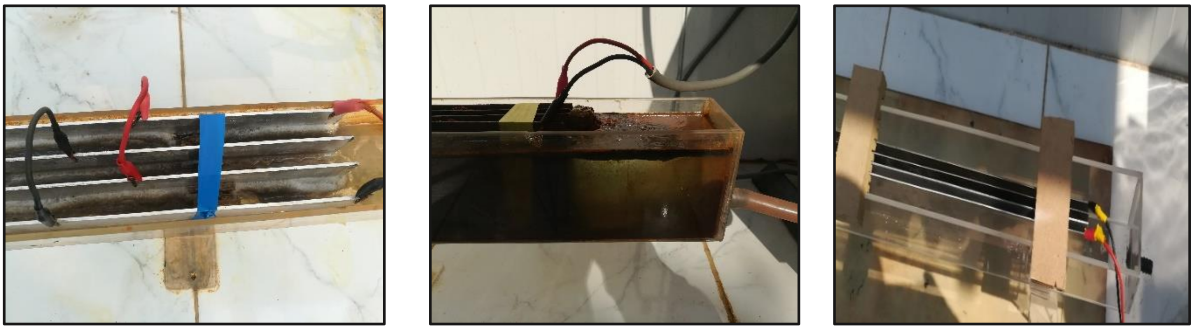
The tools used in this study involved of Feed tank, Perspex channel, reactor, electrode, and power supply. Domestic wastewater was placed in the tank. Then the wastes were forced into the reactor, which has an electrode sheet. The electrode sheet is connected to the power according to the anode and cathode used and uses different types of Electrodes Stainless Steel, Iron, and Aluminum with different electric currents of 4,6,12,17 volts and change distance between electrodes 1cm and 2cm.

3.1. When the spacing between electrodes is 1cm

In case the spacing between electrodes is 1cm the experiment was carried out on three different metals of electrodes Stainless steel, iron, and aluminum, this equation was used to compute the wastewater efficiency of removal of COD, BOD, fecal coliform and total coliform in the treatment experiments was [9].

$$CR = \left(\frac{C0 - C1}{C0}\right) * 100 \qquad \text{Equ 1}$$

CR is the removal efficiency percentage; C_0 is the initial concentration of wastewater before electrocoagulation in mg L^{-1} and C_1 is the concentration of wastewater after electrocoagulation in mg L^{-1}



a) Aluminum b) Iron c) Stainless Steel

Fig.4. Different types of electrodes a) aluminum, b) Iron, c) Stainless steel with the spacing between electrodes 1cm

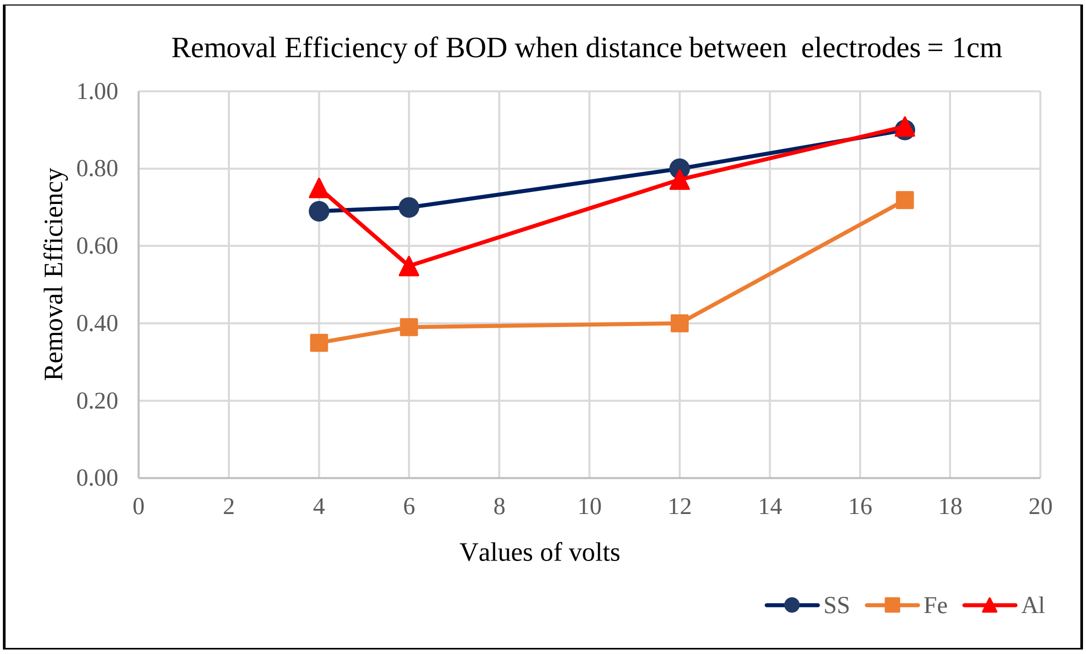


Fig.5. Removal Efficiency of BOD with different types of electrodes when d = 1cm

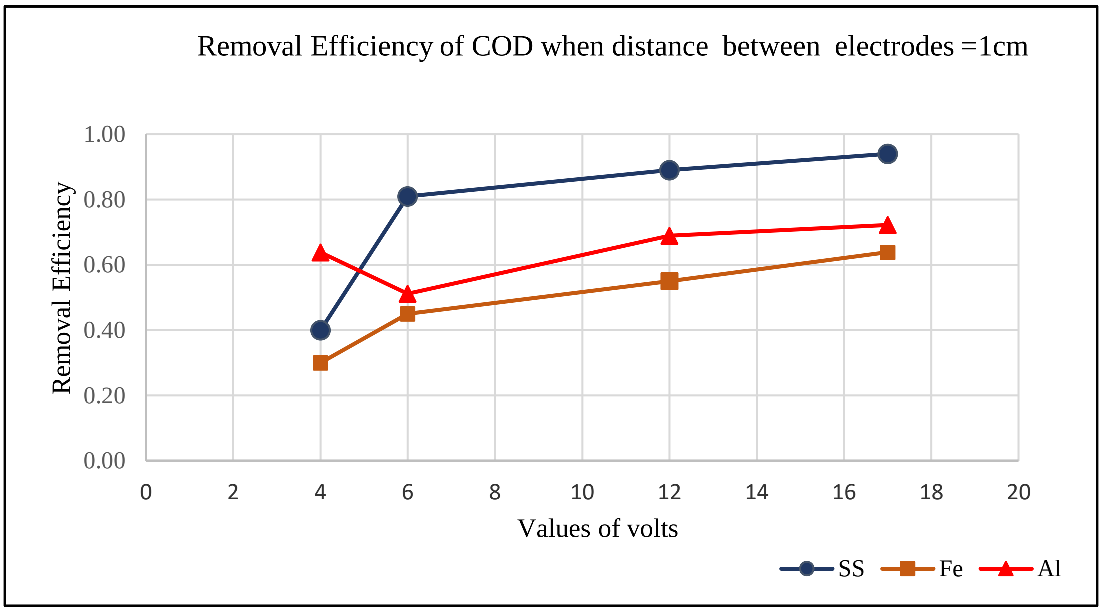


Fig.6. Removal Efficiency of COD with different types of electrodes when d=1cm

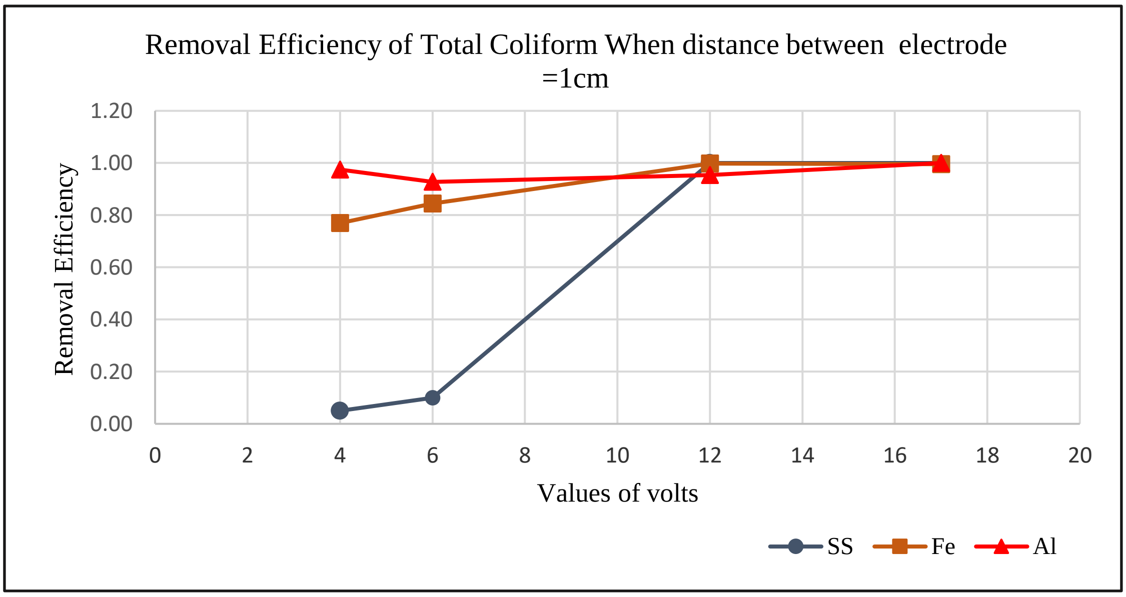


Fig.7. The efficiency of removal Total coliform with different types of electrodes when d =1cm

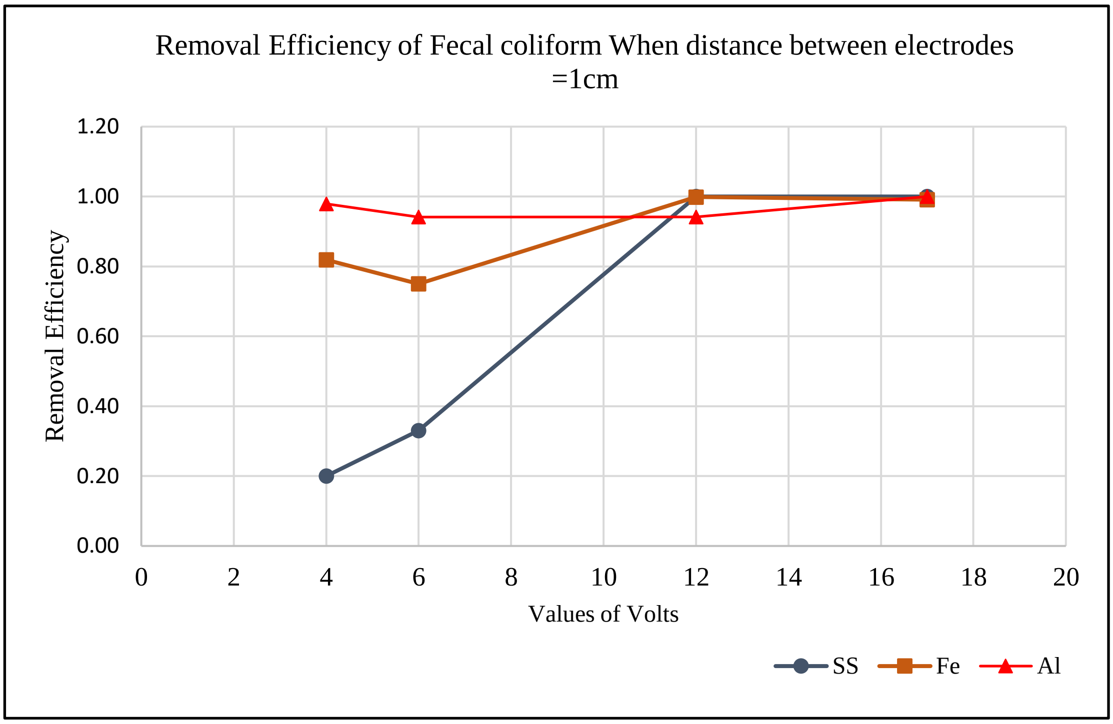
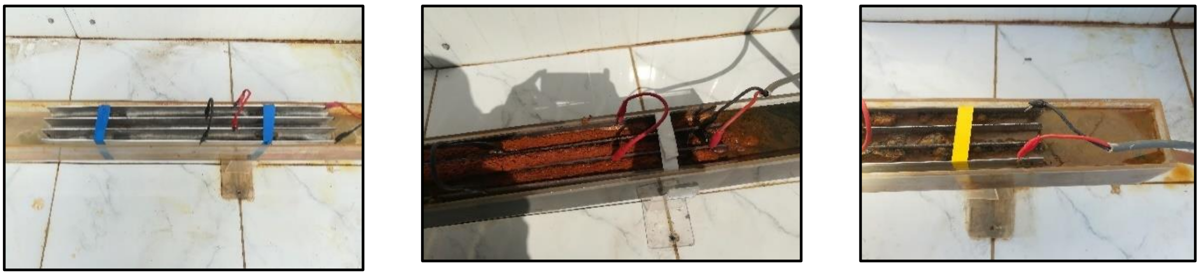


Fig.8. Removal Efficiency of Fecal Coliform with different types of electrodes when d=1cm

3.2. When the spacing between electrodes is ٢ cm

In this section the case of 2 cm spacing between electrodes with made of Stainless steel, iron, and aluminum separately.



a) Aluminum b) Iron c) Stainless steel

Fig.9. Different types of electrodes a) aluminum, b) Iron, c) Stainless steel with the spacing between electrodes 2cm

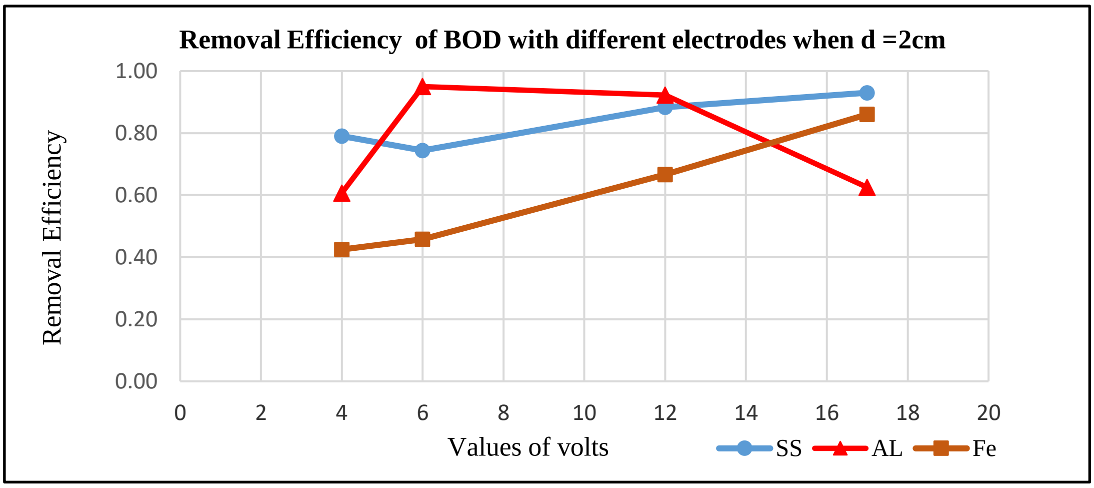


Fig.10. Removal Efficiency of BOD with different types of electrodes when d=2cm

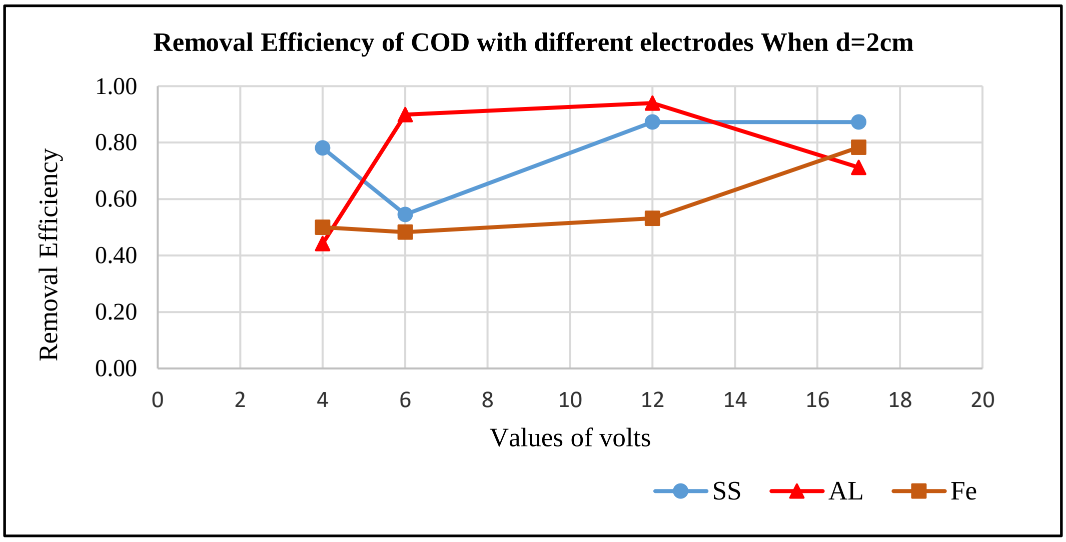


Fig.11. Removal Efficiency of COD with different types of electrodes when d=2cm

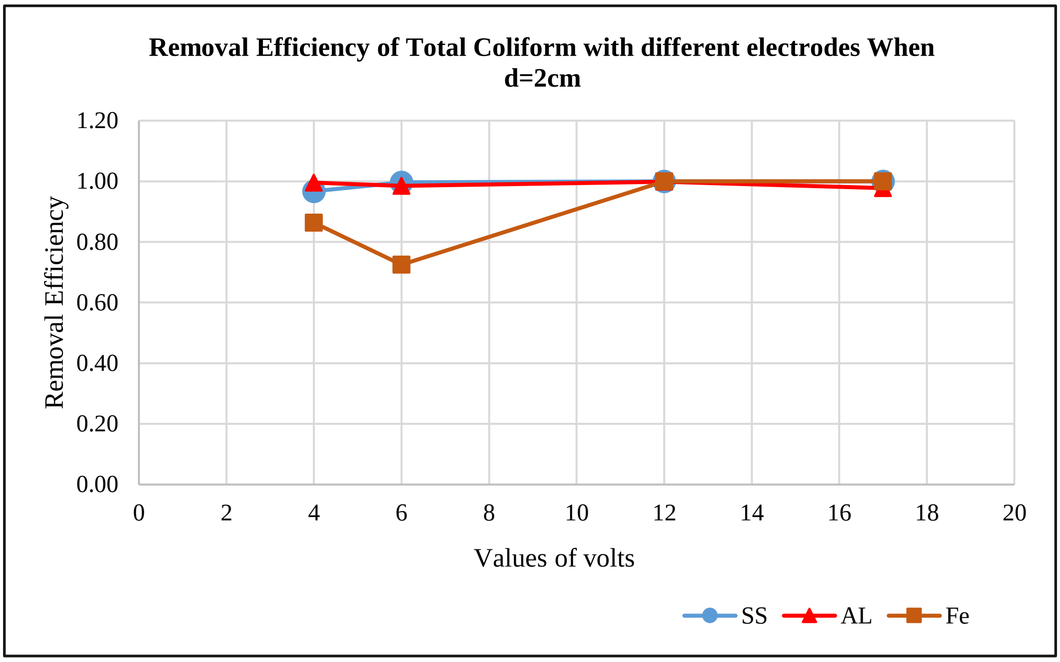


Fig.12. The efficiency of removal of total coliform with different types of electrodes when d=2cm

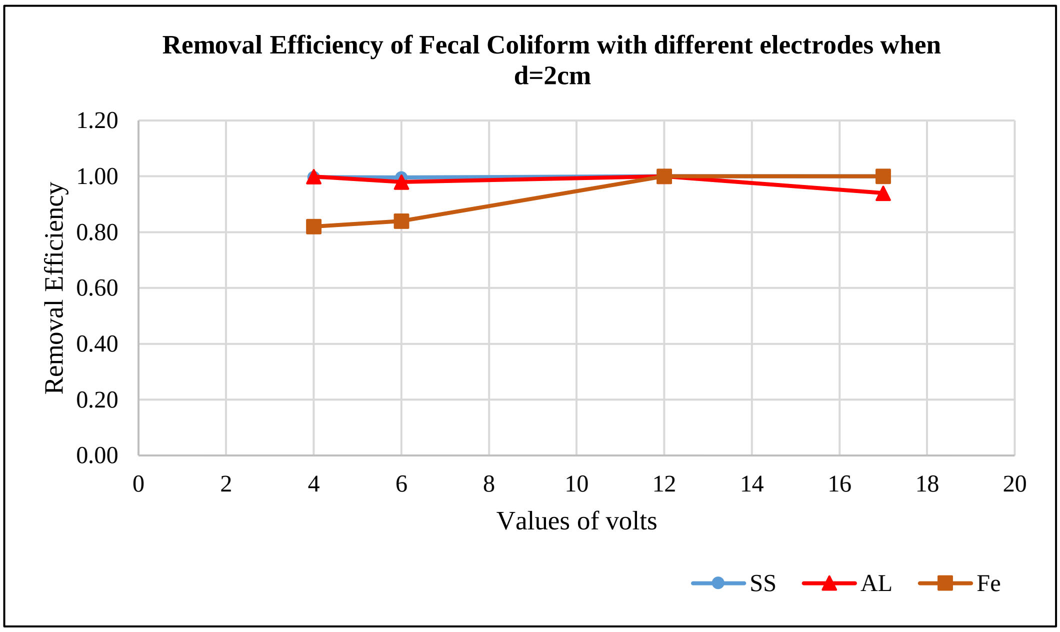


Fig.13. The efficiency of removal of fecal coliform with different types of electrodes when d=2cm

4. Discussion of results

In an EC experiment, the electrode (sheets of metal) is usually linked to a power supply (DC source). The quantity of metal melted is dependent on the amount of current delivered through the electrolytic liquid

4.1. Types of electrodes

Electrode get-together is considered the core of the current treatment ability. The record common sheet materials for electro-coagulation are aluminum, iron, and stainless steel. In this experimental removal, effectiveness was used for BOD, COD, fecal coliform, and total coliform when the space between electrodes =1cm as shown in Fig (5,6,7,8) with different volts for Stainless Steel, iron, and Aluminum, and the removal efficiencies for BOD, COD, fecal coliform and total coliform when the spacing between electrodes =2cm as in Fig (10,11,12,13) with different volts for Stainless Steel, iron and Aluminum. The discharge treated with the iron electrode was observed firstly as green liquid and then changed to yellow liquid and muddy in the first minutes. Mixing between green and yellow colors can may be led to Fe^{2}+ and Fe^{3}+ ions being created during theEC process (brownish color). Fe^{2}+ is the collective ion produced in situ of electrolysis of iron sheet. It has reasonably high soluble in acidic or neutral situations and can be dissolved simply into Fe^{3}+ by liquefied oxygen in water [10] when the waste was treated with an aluminum electrode seemed like the first time white and stay white all the procedure, no sludge was stable observed, only white foams are designed as the electrode was corroded and liberated trivalent aluminum (Al^{3}+). The (Al^{3}+) results from an ionic combination with the contaminant of wastewater contents magnesium and calcium. There was the formation of a hard coagulant. Excellent coagulation and flocculation were seen. The Stainless steel electrodes were used to treat the waste discharge in the first method general, the electro-coagulation method grows due to the creation of metallic hydroxide types that adsorbed the contaminants particles, and these reasons for the increase of the efficiency of removal.

4.2 Spacing between electrodes

To study the effect of electrode spacing on the electro-coagulation method for the elimination of contaminants from sewage, Dissimilar spaces between the electrodes were practical. Due to Bukhari [11] rise in the spacing of the electrodes will decrease the cost of treatment but might decrease the behavior efficiency. Inter electrode spacing of 1, 2 cm was planned to study the effect of spacing of electrodes on the EC process for Stainless steel, Aluminum, and iron electrodes.

The analysis reveals that the efficiency of removal for the EC method for BOD, COD, Total Coliform, and Fecal Coliform increased with the decrease in the internal electrode spacing. for BOD, COD, total Coliform, and Fecal Coliform an inter-spacing electrode of 1 cm marked a significant percent of removal at 3.5 Hours for all types of electrodes.

Moreover, the odor was disappearing with stainless steel, iron, and aluminum electrodes, and the color of the sample had transformed to colorless for all types of electrodes.

4.3 Characteristics of Sewage waste

The sewage wastewater under this research has physical properties that appear to be particles of suspended materials with a brown color. Further testing is shown on the raw sewage water to determine, COD, BOD, total coliform, and fecal coliform. The results are in the following table (1).

Table. 1. Characteristics of raw sewage water

Physicochemical Parameters	Units	Parameters of wastewater used in Experimental
Biological Oxygen Demand (BOD)	mg/l	43
Chemical Oxygen Demand (COD)	mg/l	113
Microbiological Parameters		
Total Coliform	CFU/100ml	12.9×10^{4}
Fecal Coliform	CFU/100ml	10.9×10^{4}

Conclusions

The different electrode materials affected the efficiency of wastewater behavior because of their mechanisms Stainless steel electrodes recorded the highest removal in BOD, COD, Total coliform, and Fecal coliform than aluminum. Iron (Fe) electrodes have good removal efficiency also we can practice wastewater treatment as it is the economic one.

The practical volts have a vital result on the efficiency of elimination of the EC process. It was found that increasing the volts (4,6,12,17) increases the removal efficiency for studied pollutants, with the case of 1cm with12 volts is the best to remove pollutants from sewage water for all items but in the case of 2cm the best volt is 12 for BOD, COD, Fecal coliform and total coliform and use 6 volts but the quality of water,in this case , is less than the case of 1cm but the water quality in this case agreement with water properties in law 92 art 52.

Electro-coagulation is a promising approach for wastewater treatment. On the other hand, the cost of this method is considered cheap while using an iron but the best for treatment uses Stainless steel.

Recommendation

1. When using the electrodes and placing them in the drain, farmers must be made aware of their importance and preserve them to reuse them again in treatment.

2. It is preferable to use 10 L/hr with 12 volts to get the best and fastest treatment results and spacing between electrodes =2cm.

3. It is necessary to research in this field to find an easy way to apply this research in a simple way on the ground.

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