Removal of Pathogenic pollutants using electrocoagulation using aluminium electrodes

Shereen A Abdul-Husain¹, Sawsan Alramahi²
¹ Department of Civil Engineering, College of Engineering, University of Warith AL-Anbiya’a, Kerbala, Iraq.
Email: Shereen@uowast.edu.iq

Abstract. Pathogenic contamination of fresh waste bodies is some of the most harmful types of water contamination where in aquatic environment the pathogenic microorganisms can reproduce, which may pollute the marine environment overall. In addition, there are serious side effects with microbial infection. Some many pasteurization processes, like membrane separation and additives, have therefore been used to remove microorganisms from wastewater. Most of these processes are inefficient or hazardous, like the chemical treatment. Lately, electrocoagulation process, due to the environmental safety and comparatively low operational costs, has paid considerable attention to remove pathogenic contamination of sewage treatment plant effluent. During this analysis, the consequences of the changing of the electrical current change from 0.5 to 1.5 mA/cm² were examined on the ability of aluminium-based electrocoagulation unit for sewage treatment by disabling pathogenic pollutants. The findings demonstrated that the density of the current was increased to increasing the E. coli elimination (an indicator of pathogenic pollutants removal) to reach a current density of 2 mA/cm² the strongest deactivation (83.2%). Rising the current density increases the bacterial removal. However, the increase in the current density increases the treatment cost.

Keyword: Electrocoagulation, pathogenic contamination, aluminium.

1. Introduction
The population of the world is now subjected to various pollution sources, such as water, air, and soil pollution, which adversely affect human welling and life on earth [1, 2]. The contamination of the water, which can be described as the existence of undesirable contaminants in water, is an emerging burden due to wastewater disposal or the normal occurrence of a contaminant's overconcentration [3-5]. The contamination of the water is regard as one of the most harmful type of contamination due to the low volume of potable water on this planet which is less than 0.3 percent of earth water bodies and because the incapability of people to live without water for very short time [6-8]. In everyday lives, industrial sector and large-scale farming also contribute to a worrying trend towards contamination of water bodies both ground and surface water bodies [9-12]. One clear indication is a 75% rise in water bodies phosphate quantity compared with its pre-industrial revolution concentrations [13, 14]. Regrettably, like phosphorus, the levels of certain pollutants rose by so many times owing to industrialisation, include but are not restricted to nutrients [15-18], toxic substances [19-23], dyes [24, 25], fluoride [26-29], phenols [30], and organic material [31]. Water problems have been more severe because of the effect on water use of climate change[32-36], sharing on Earth planet of water and
people[37-41]. The oil industry which has been exponentially expanding over the last decade, for example, generates large quantities of wastewater containing high levels of toxic toxins, like arsenic, organic compounds, and biological contaminants. As described earlier, water contaminants, including toxic substances, phenols, painting chemicals, organic compounds and fertilizer, are sadly endless, leaving about half of the total worldwide population lacking healthy water supply in the upcoming years [42-45].

Biological contaminants are regarded as the most hazardous contaminants among water contaminates owing to their potential to substantial increase in numbers inside the water in comparatively short times and their serious effects on human health [22, 46]. Exceeding 1 million people have been confirmed to die worldwide annually due to diseases linked to water contamination. In addition, it has been identified that a significant number of water bodies are biologically contaminated in developed nations; for example, approximately 1/3 of Bangladesh's underground water sources were considered contaminated with biological pollutants. The lack of successful techniques of sterilization, in particular in developing countries, actually increased the biological contamination of water bodies [22]. Accordingly, many disinfection processes, including chlorine, UV radiation, magnetic charges and metallic salts, have been used to eliminate microbial contaminants from polluted water [21]. In a synthetic wastewater which includes toxic metals, nanoparticles of magnesium metal oxide have been used to disable the E. coli, and it was found that nanomaterials of magnesium metal ions completely kill all E. coli in 30 minutes treatment [47, 48]. Many technologies, though, are costly like nanoparticles or dangerous because they are producing toxic by-products like chlorination and chemical treatment [49]. Furthermore, certain technologies like biological reactors produces huge sludge volumes that involve costly dewatering processes before they are disposed of [50] or adopted as recycling materials [51-57].

In contrast to many other approaches, current advances of the electrocoagulation (EC) as a disinfection procedure for polluted wastewater have shown that biological contaminants can be removed within such a short amount of time [3, 28, 58]. The EC processes are also incredibly safe since there is no need of chemicals to be add to the water and harmful by-products from the reaction will not be generated [49]. To give a good instance, over 95 percent of Escherichia coli can be removed from of the artificial water sample in just about twenty minutes at a low operational cost, using Aluminium alloys EC units [49, 59]. In addition to the afore mentioned benefits, automating EC reactors with a suitable form of detectors like heat wave detectors is very simple [60-63]. Nevertheless, the effectiveness of the EC systems was also shown to rely on a number of operating factors like applied voltage, current density and adsorbent dosage [1, 16]. The effects of the density of the current on the removal of the E. coli's from municipal wastewater were investigated in this research.

2. Materials and methods

2.1. Experimental Setup

Experimentation was started using a 1500 mL (shape cylinder) plastic container, consisting of two aluminium electrodes. each electrode has a surface area of 450 cm2. Tests were initiated electrocoagulation device Because of its economy, large accessibility (including in underdeveloped nations), its low oxide potential, aluminium was included in this device [2]. Two holes were attached to the container, the high hole was used as an entrance for the liquid, the lower hole was used as outlet to extract samples to further analyse. To provide regulate the needed current density, the aluminium electrode was directly coupled a DC source of power.

The treatment using the EC was performed by the addition of 750 mL of the sample prepared within the device, and the supply voltage for the appropriate duration was turned on. All parameters of operation are maintained in all tests, except for the applied voltage. The experiments were conducted at 7.5 pH level (the true pH of the sewage specimen), time is 20 minutes and the temperature kept at 20 °C. The density of the electrical current density has been selected as a control variable in this analysis, as it...
played a huge part in the Ec system. The density of the electrical current has been demonstrated to regulate the thermal degradation of electrode (generating metal oxides), which regulate the quality of elimination of selected contaminants [5]. Besides, cathodes are often used to produce Hydrogen ions that is accountable for raising the coagulated contaminants in foam onto the solution's surface [5]. The treatment method has been introduced at three separate current densities that are 0.5 mA/cm², 1 mA/cm² and 1.5 mA/cm² to examine the impact of the current density on the elimination of the microbes from municipal sewage. The performance of neutralization of the bacteria using the EC technique was measured using the following equation [49]:

\[
\text{Neutralization(\%)} = \frac{\text{Start cell count} - \text{End cell count}}{\text{Start cell count}} \times 100
\]  

The current density influence was measured based on the power usage of the aluminium EC using following equation:

\[
\text{Energy (kWh/m}^3\text{)} = \frac{\text{Current density (ampere)\times Cell potential (voltage)\times treatment time (hour)}}{1000 \times \text{Volume of water sample (m}^3\text{)}}
\]  

2.2. Wastewater samples

During February 2020, a sewage samples were taken utilizing plastic bottles at Karbala wastewater treatment plant, situated in the city of Karbala, Iraq where each sample has a size of 3 litres capacity. The E. coli cells were used as indicator to investigate the performance of the EC system in terms of bacterial disinfection of municipal wastewater. The analytical procedure was undertaken based on the current methodology proposed by the American Public Health Association using the filtration membrane technique. After 24-hour incubation time at 35 °C, the number of E. coli colonies was recorded before and after the sewage treatment.

3. Results

The electrical current density regulates the removal of contaminants, as was discussed in earlier part of this research, through both regulation of the generated metal oxides and hydrogen ions within the EC reactor. The results of changing the current density of the neutralization of the E. coli have been examined using 0.5 and 1 and 1.5 mA/cm². The pH level of the sewerage was 7.5 and the treatment duration was 20 minutes. The temperature of the samples was 20 °C and the size was 1500 mL. The influence of the electrical current density on the neutralization of the E. coli is presented in Figure 1. The removal efficiency of E. coli was found to boost with elevated current densities. it was found that it was at a current density of 0.5 mA/cm², the removal percentage was about 35 percent and increased significantly to be around 83.5 percent using a current density of 1.5 mA/cm². As stated above, the change in the neutralization of E. coli at elevated current stems from a rise in the quantity of metal oxides produced and the production of the hydrogen ions, resulted in a significant enhancement in E. coli neutralization.
Figure 1: Electrical current density influence on E. coli removal.

Figure 2 shows the detrimental consequences of raising the current density. The raising current density leads to a significant rise in energy usage. The current density increased from 0.5 to 1.5 mA/cm$^2$ led to an increase the electricity usage from 2.1 to 6.3 kW/h/m$^3$. Because of these findings, while existing densities is highly useful for the elimination of biological contaminants from water, their performance must be improved such that high energy losses can be avoided. Furthermore, the efficiency of the aluminium EC have been noticed to be in reasonable accordance with the literature [49].

Figure 2: The power usage based on the current density supplied.

4. Conclusion

The present work was carried out to assess the impact on the neutralization of E. coli by the EC approach of the current density. The findings revealed that the current density should never be overlooked in the electrocoagulation removal method of microbial from swage, and the neutralization of E. coli improved approximately 50 percent by raising the current density from 0.5 to 1.5 mA/cm$^2$. This shows that the efficiency of aluminium EC can be enhanced by increasing the density of the electrical current. Nevertheless, the high-power usage increases energy demand, and hence the use of aluminium EC systems in the area of sewerage treatment may be limited. Additionally, parameters like electrode spacing and sewage temperature also play a significant role in the EC process, and further experiments must be conducted with the effects of the experimental variables on E. coli removal from sewage.
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