Investigation of electrocoagulation reactor design parameters effect on removing hardness from drinking water using iron electrodes

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Abstract: In this work, the hardness removal efficiency was studied from groundwater taken Jaffna peninsula which was used to drinking. Electrochemical cell was constructed using six iron electrodes. The electrodes were connected to a power supply that provides direct electrical current to the cell. Results showed that a removal efficiency of 85% can be obtained at alkaline medium and electrical voltage of 20 volt with retention time of 60 minutes. The high efficiency for hardness removal suggested that the electrochemical technique might be used as an alternative technique for hardness removal.

Introduction

Jaffna peninsula is the northern end of the Northern Province of Sri Lanka. Groundwater is the major natural water source in the Jaffna peninsula and it is used for domestic, agricultural and industrial purpose. One of the undesirable characters is excessive hardness. Calcium and magnesium dissolved in water are the two most common minerals that make water "hard." World Health Organization's recommendation limit is 200 mg/l, but in Jaffna average concentration in the ground water is more than 350 mg/l. There are following concerns associated with drinking water with excessive hard water High risk for cardiovascular diseases, Unfavourable taste for drinking, Deposition in the supply pipe lines and Scaling in kitchen vessels. Electrocoagulation is the advanced technology used to remove hardness from drinking water. The aim of this study was to investigate electrocoagulation electro coagulation reactor for removing hardness from drinking water using iron electrodes and the effect of experimental parameters electrical potential, surface area to volume ratio and contact time.

Material and methodology

Collection of water samples

Jaffna peninsula was selected for this study. Ten wells were selected in different areas with different kinds of water in Jaffna Peninsula. Those areas were Jaffna hindu junction[1], Maviddapuram[2], Alaveddy[3], Municipal water[4], Nilavarai[5], Chunnakam[6], Nachchimar kovil[7], Velanai[8], Sivanpannai[9], and Chankanai[10].Each water samples were poured in to 15l plastic can after rinsing several times with the sample water. Plastic can was tightly closed and labelled. Then samples were taken into the laboratory for chemical analysis.

Raw water and filtered water samples were analysed for PH, Electrical conductivity (EC), and total hardness.EC and PH were measured by Electrical conductivity meter and pH meter, was determined calorimetrically by spectrophotometer, and Ethylene Diamine Tetra Acetic acid (EDTA) titration was used to estimate the total hardness based on the guideline of Sri Lanka Standard 614: part 1.

Operation of Electro coagulation unit

The electrocoagulation cell used in this study is schematically shown in Fig. 1.1. Net volume and effective volume of batch cell is 6.75 and 4.5 liters, respectively. The materials used in this study were six iron electrodes (14cm×30.5cm×5mm. Six plate electrodes with total effective area of 0.336 m2 were used. The distance between electrodes was kept constant at 1cm.Electrodes were connected to the positive and negative terminals of the DC power supply (GwINSTEK, GPS-3303, 0-3A, 0-30V) in a monopolar mode and dipolar mode. Before each run, electrodes were washed with water in order to remove dust from the electrode plates. To prevent passivation of electrodes, cathode and anode were changed every test during experiments. All experiments were accomplished at room temperature.

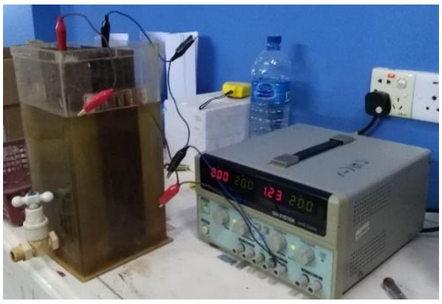

Figure 1.1 Electrocoagulation batch reactor setup

Results and discussion

Effect of applied voltage

Experiments were performed at three different voltages 10,20 and 30V at 20 min time. Base on Fig 1.2 Hardness decreased during electrocoagulation and higher voltage input give faster Hardness decreasing. The Hardness decreasing on 20V and 30V give better result than 10V voltage input. However, even Hardness decreasing also occurred on 30V, but there was no significant difference between 20V input voltage However, the cost of the process is determined by the consumption of the sacrificial electrode and the electrical energy which economically are the advantages of this method Generally, the electrical potential of 20v is required for achieving the desired efficiency. These findings are in line with the results of Malakootian et al study in 2004 in relation to removal of hardness from water

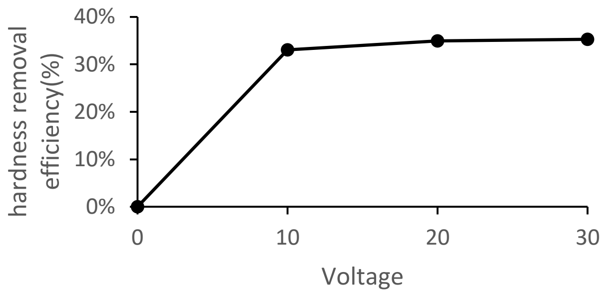

Figure 1.2 Efficiency of hardness removal with different voltages

Monopolar Dipolar comparison

There were two possible arrangements Monopolar and dipolar in parallel connection. In monopolar systems, all the anodes are electrically connected and similarly all cathodes are also connected. In bipolar systems, only the outer electrodes are connected to a power source and the current passes through the other electrodes. In the bipolar systems, the side of the electrode facing the anode is negatively polarized and vice versa on the other side facing the cathode Fig 1.3 shows better removal efficiency when the electrodes were in the dipolar arrangement rather than mono polar electrodes

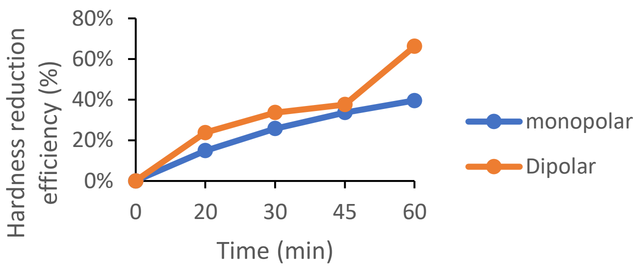

Figure 1.3 Efficiency of hardness removal with different electrode configuration

Surface area to volume ratio

The surface area to volume ratio (S/V) is an extremely important reactor design parameter in Electrocoagulation. This ratio, whose unit of measurement is known as m^{-1}, is the ratio of the active surface area of the volume of the treated solution. EC tests were performed for the S/V ratio values: 37.34, 49.78 and74.67 m^{-1}. As per the fig 1.4, Hardness reduction efficiency shown the positive correlation between S/V ratio. It had to be large enough as required by the active surface but it was limited by the width of the reactor to ensure homogeneity the larger was the S/V ratio

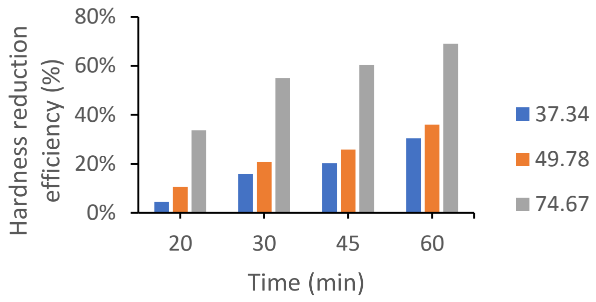

Figure 1.4 Efficiency of hardness removal with different S/V ratio

Effect of initial pH

It has been established that pH is an important operating factor influencing the performance of electrocoagulation process, iron is more efficient in neutral and alkaline medium, especially between 6 < pH < 9.(Kobya *et al*, 2003) Base on Fig 1.5 Hardness decreased during electrocoagulation and higher pH input give faster Hardness decreasing. The Hardness decreasing on 8.27and 9.06 give better result than 7.1 pH. In the case of iron electrode alkaline medium shows better reduction.

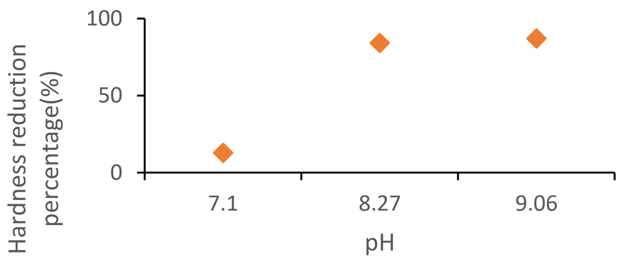

Figure 1.5 Efficiency of hardness removal with different initial pH

Running time

According to the Fig 1.6, the reduction percentage was increasing with Electro coagulation running time. Average Hardness reduction efficiency at 20, 30, 45 and 60 minutes are 37,61,75 and 85, respectively. of the hardness has been removed in the beginning of process. there is not much difference was observed between 45 minutes and 60 minutes running. So higher time running is not efficient treatment.

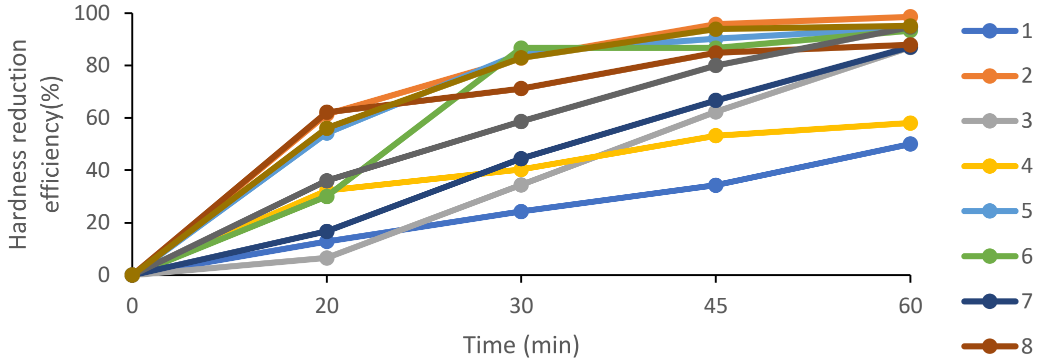

Figure 1.6 Efficiency of hardness removal with Time

Conclusion

Results of this study showed that Electrocoagulation could be used for removing ions responsible for water hardness. The greater removal efficiency has occurred in pH=9, voltage 20 and in time course of 60 min; which was 85% for total calcium hardness. further studies should be carried out for reduce the retention time and removal of residual iron.

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