Effects of current, electrodes spacing and operational time on the removal of heavy metals from primary treated municipal wastewater using dielectrophoresis.

Presented by: Abdulkarim Almukdad and Radwan Alfahel
Supervised by: Dr.Alaa AlHawari

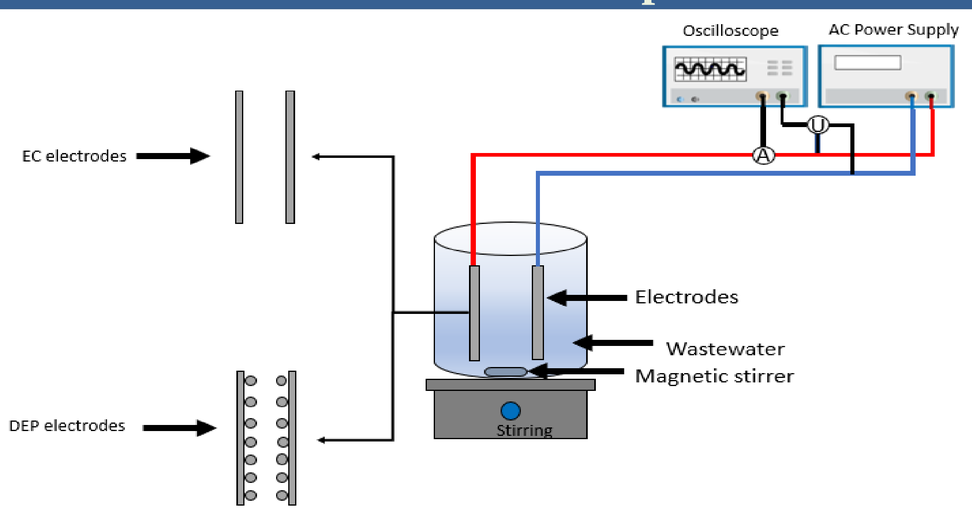
Abstract

Electrocoagulation (EC) is an emerging technology that has been used to treat heavy metals from different kinds of wastewater. This paper discusses the effects of inducing Dielectrophoretic (DEP) force in EC system for the treatment of heavy metals from primary treated municipal wastewater. In order to achieve the optimum run of DEP, COMSOL software was used to identify the highest force that can be obtained by changing electrodes spacing and applied current. As per the results obtained from experiments and numerical methods, the optimum run was at operational time of 30 min, electrodes spacing of 0.5 cm and applied current of 600 mA (17.14 mA/cm2 current density). In both process aluminium electrodes were used and they were connected to alternative current (AC) power supply. The efficiency of AC-DEP was found to be better than AC-EC. The removal efficiencies of Fe and Mn using AC-DEP were 80.6% and 29.7% respectively, while AC-EC removed 78.23% of Fe and 28.8% of Mn. Moreover, the increase in the aluminium content using AC-DEP and AC-EC was 810.3% and 1330.8% respectively. Furthermore, the energy consumption of AC-DEP was 4.9 kWh/m3 while AC-EC consumed 5kWh/m3.

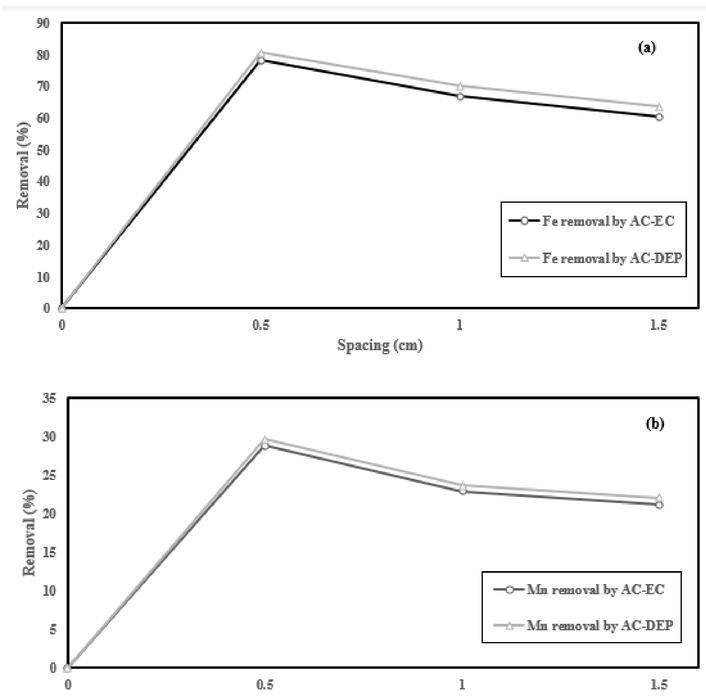
Introduction

The presence of heavy metals has been reported worldwide in many natural bodies of water at a concentration levels of few μg/L.[1,2] Heavy metals are considered as highly toxic elements. They may accumulate in the human body as a result of contaminated water or food. The accumulation of heavy metals inside the human body could result in serious health disorder [3]. Municipal wastewater is known to be rich with multiple pollutants including heavy metals. Therefore, it is necessary to remove the heavy metals from the wastewater before discharging it to any natural water body. Heavy metals are usually removed from wastewater using conventional process such as chemical precipitation, ion exchange and electrochemical removal. The removal of heavy metals using conventional processes has several disadvantages such as production of toxic sludge, low removal efficiency and high energy consumption. As a result of those disadvantages, electrocoagulation was encouraged to be used for the treatment of several industrial wastewater in many studies.

Schematic Setup

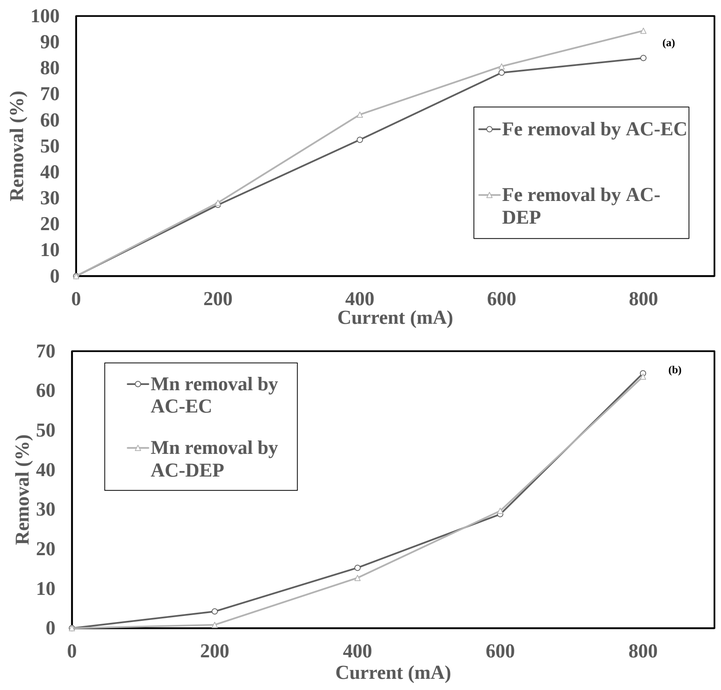


Impact of electrodes spacing on Fe and Mn Removals



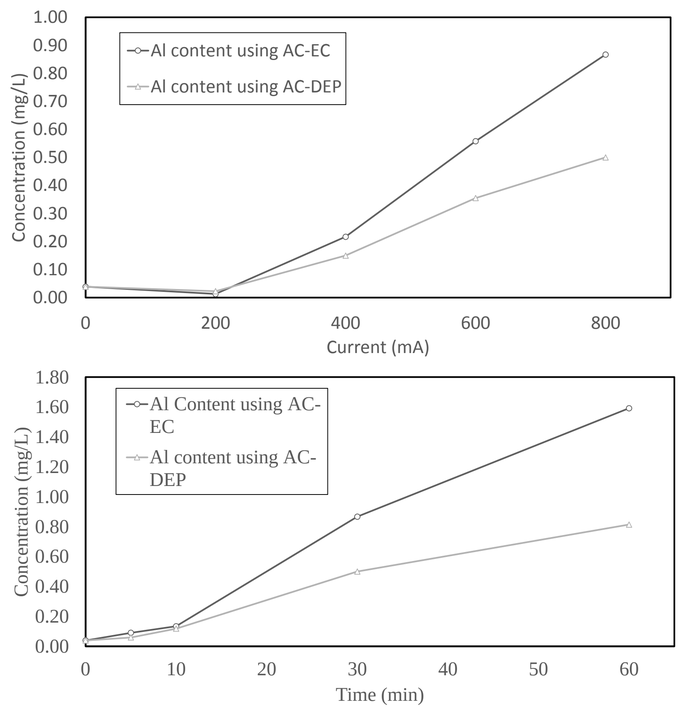
- At electrode distance 0.5 cm, the removal % of Fe using (AC-EC) and (AC-DEP) were 78.8% and 80.3%, respectively.
- At electrode distance 0.5 cm, the removal % of Mn using (AC-EC) and (AC-DEP) were 28.8% and 29.6%, respectively.

Impact of applied current on Fe and Mn Removals



- The Fe removal % was almost 80 % at applied current 600 mA in both (AC-EC) and (AC-DEP) modes. The maximum removal % of Fe was 94.3% obtained using an applied current 800 mA in (AC-DEP) mode. While (AC-EC) mode, removed 83.9% of Fe.
- The Mn removal % increased to almost 30 % using an applied current 600 mA in both (AC-EC) and (AC-DEP) modes. The maximum removal % of Mn was 63.3% obtained using an applied current 800 mA in both (AC-EC) and (AC-DEP) modes.

Impact of electrolysis time and applied current on the increase of aluminum content in the solution



- The aluminum content was 0.867 mg/L (AC-EC) and 0.50 mg/L (AC-DEP) using applied current of 600 mA and electrolysis time of 30min. At 60 mins of electrolysis time and applied current of 600 mA, the aluminum content of (AC-EC) was almost two times higher than (AC-DEP).

Energy Consumption

Conclusion

- Optimum condition: 0.5cm electrodes spacing, 30 mins electrolysis time and 600 mA applied current
- Fe removal efficiency: 80.6% using AC-DEP and 78.23% using AC-EC
- Mn removal efficiency: 29.7% using AC-DEP and 28.8% using AC-EC
- Al content: 0.5 mg/L using AC-DEP and 0.867 mg/L using AC-EC
- Energy consumption: 4.9 kWh/m3 using AC-DEP and 5 kWh/m3 using AC-EC

References:
[1] M.S. Bhuyan, M.A. Bakar, A. Akhtar, M.B. Hossain, M.M. Ali, M.S. Islam, Heavy metal contamination in surface water and sediment of the Meghna River, Bangladesh, Environ. Nanotechnology, Monit. Manag. 8 (2017) 273–279.
[2] J.A.R. Martín, C. De Arana, J.J. Ramos-Miras, C. Gil, R. Boluda, Impact of 70 years urban growth associated with heavy metal pollution, Environ. Pollut. 196 (2015) 156–163.
[3] S. Babel, T.A. Kurniawan, Cr (VI) removal from synthetic wastewater using coconut shell charcoal and commercial activated carbon modified with oxidizing agents and/or chitosan, Chemosphere. 54 (2004) 951–967.