Evaluation of Electrocoagulation and Fenton's reagent for Arsenic removal from drinking water

Ms. ASMITA JADHAV
Research Scholar,
CSIR-National Environmental Engineering Research Institute,
NEERI, Nagpur
India
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Objectives of the research

- Review of existing arsenic removal technologies for potable water supply.
- To study and develop a treatment technology for the removal of arsenic from drinking water to meet the maximum contaminant level of Arsenic based on electro-coagulation using iron electrode
  - Laboratory experiments for arsenic removal
  - Experimental Parameters
    - Current Intensity
    - Initial Arsenic Concentration
    - Iron concentration
    - pH
- A comparative study of arsenic removal by Electrocoagulation Vs Fenton’s reagent.
Electrocoagulation

- EC involves the generation of coagulant in situ by dissolution of metal from the anode with simultaneous formation of hydroxyl ions and hydrogen gas at the cathode.

- This process produces the corresponding aluminum or iron hydroxides and/or polyhydroxides, with the added benefit of the gas generated assisting in bringing the flocculated particles to the surface while providing them additional buoyancy to float at the water surface.

Fig. Schematic representation of Electrocoagulation-cell
Arsenic removal by Electrocoagulation

Laboratory Scale Batch Electrocoagulation:

❖ 15L Electrochemical Batch Reactor

❖ Iron Electrodes (99% purity, 2 mm thickness; effective area 180 cm² on each side)

❖ The plates were placed 10mm apart in the batch cell.

❖ The mono-polar 3 electrodes connected in parallel were used in electrocoagulation cell for the experiments.

❖ A direct current (DC) supply (TESTRONIX 34C, 1 - 15V, 0 - 5 A, Digital Display)
Arsenic removal by Fenton's Reagent

Experimental Set-up For Fenton's Reagent:

- The batch process was carried out in plastic buckets of 15L capacity.
- It consists of two plastic buckets of 15L capacity with outlet arrangement.
- The outlet was made by using 12mm PVC pipes and the outlet point of the pipe is kept higher than the top layer of fine sand by 5 cm.
- This arrangement was made for creation of a permanent bio film layer above the sand layer(The assembly is followed by slow sand filter).
- A plastic barrel was used for the collection of treated water.
Results: Electrocoagulation

Effect of pH on arsenic removal:

Effect of initial arsenic concentration at pH 3.5 and 0.5 A

Effect of initial arsenic concentration at pH 3.5 and 1 A

Effect of initial arsenic concentration at pH 6.5 and 0.5 A

Effect of initial arsenic concentration at pH 6.5 and 1A
Effect of initial arsenic concentration at pH 9.5 and 0.5 A.
Effect of Initial Arsenic concentration

The EC experiments were carried out in the range 75-200µgL⁻¹ for evaluation of arsenic removal efficiency at 0.5 - 1A on 6.5 pH of drinking water as on this pH according to the results shows best efficiency.

Figure: Removal Efficiency (%) of Arsenic at pH 6.5 and 0.5A
It was observed that higher initial concentration such as 200µgL\(^{-1}\) took more time to reach below 10µgL\(^{-1}\). Figure, For 100µgL\(^{-1}\) the removal efficiency was higher than 92% whereas for 200µgL\(^{-1}\) the removal efficiency was 84% at 0.5 A.

Figure: Removal Efficiency (%) of Arsenic at pH 6.5 and 0.5A
Variation of pH with time

The pH of raw water was increased in electrocoagulation with time as shown below in Figure.

Figure: Variation of pH with Time at 0.5A

Figure: Variation of pH with Time at 1A
Figure: Effect of Current processing time on Residual Arsenic concentration at pH 6.5 with initial conc. 100µgL⁻¹.
Arsenic removal using Fenton’s Reagent

Arsenate Removal Efficiency Using Fenton’s Reagent

- Arsenate conc.: 100 ppb
- Flow Rate: 120 ml / min

- Arsenate Removal Efficiency %
- Residual Arsenate Conc. (ppb)

Arsenate Removal Efficiency Using Fenton’s Reagent

- Arsenate conc.: 500 ppb
- Flow Rate: 120 ml / min

- Arsenate Removal Efficiency %
- Residual Arsenate Conc. (ppb)

Arsenate Removal Efficiency Using Fenton’s Reagent

- Arsenate conc.: 1000 ppb
- Flow Rate: 120 ml / min

- Arsenate Removal Efficiency %
- Residual Arsenate Conc. (ppb)
Conclusion

Based on present work following conclusions are drawn:

- pH 6.5 was found to be most appropriate for treating the drinking water for arsenic removal by Electrocoagulation.

- In electrocoagulation increase in pH is observed but the increase is within safety limit prescribed by WHO (as per the limit it is safe to drink water upto pH of 8.5).

- The electrocoagulation process was able to decrease the residual arsenic concentration to 10µgL⁻¹ and meet the drinking water standard (Bureau of Indian Standard (BIS) IS: 10500: 2012) with iron electrode.

- Fenton's reagent was also feasible for arsenic removal, the experiments showed more than 98% removal efficiency for arsenic removal from drinking water.

- The comparative study of these methods revealed that both methods have advantages and disadvantages as per the operating parameters.

- These methods can be used for arsenic removal as per the requirement.

- Electrocoagulation can be a good option for community, whereas for household purpose Fenton’s reagent can be useful.
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