Application of Activated Carbon Fiber (ACF) for Zinc Removal in Aqueous Solution

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1. Introduction
Heavy metal pollution has posed a serious threat to aquatic ecosystem and human health due to rapidly increasing anthropogenic activities in the name of industrialization. Among the various heavy metals, zinc is one of the most common elements in the Earth’s crust. All heavy metals are toxic and non-biodegradable and should be separated from wastewater before they are discharged. Although a number of systems have been developed, adsorption was found to be superior to other techniques for water re-use in terms of initial cost, simplicity of design, ease of operation and insensitivity to toxic substances (Meshkho et al., 2001; Forgacs et al., 2004). Activated carbon fiber (ACF) has been widely applied to water purification systems in recent years (Donnet et al., 1993). For the extensive use of ACF in the removal of zinc from wastewater, it is required to know the optimized level of operational parameters. In this study, several series of experiments were conducted to investigate the performance of ACF for zinc removal. To optimize the system, initial concentration, flow rate and operational time were taken as the parameters for finding the removal efficiency.

2. Materials and methods
In this study, feed solution was prepared by mixing stoichiometric amounts (varies depending on the initial zinc concentration) of zinc sulfate heptahydrate (ZnSO₄·7H₂O) with distilled water. After the solution was mixed thoroughly, it was fed to the ACF apparatus and the experiment was conducted for five hours. Samples were collected every after 30/60 minutes interval. All the experiments were carried out at the ambient laboratory temperature of about 10±1°C. Experimental module consists of a feed tank, a cartridge filter followed by the two sets of activated carbon fiber (ACFs) and effluent tank. The schematic diagram of the experimental set up is shown in Fig.1.

![Schematic diagram of the experimental set up](image)

Fig.1. ACF set-up for the zinc removal from aqueous solution

Initial concentration, flow rate and operation time were the variable parameters of the study. The samples were analyzed by using Varian 720-ES ICP-OES at the wavelength (À = 213.857 nm) for
the measurement of zinc containing effluent. Similarly, statistical analysis was also carried out for the simulation of the adsorption isotherm models. The characteristics of ACF used in this experiment are summarized in Table 1.

**Table 1. Characteristics of ACF**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Conditions</th>
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<tbody>
<tr>
<td>No. of fibers</td>
<td>103</td>
</tr>
<tr>
<td>ACF BET surface area</td>
<td>1,000 m²/g</td>
</tr>
<tr>
<td>Weight of ACF</td>
<td>30 g/cartridge</td>
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3. Results and discussion

Overall Zn (II) removal efficiency was almost 99% at the second ACF filter unit for the initial zinc concentration of 50 mg/L. The % removal increased with the span of operational time in 1st ACF filter unit whereas % removal decreased with the span of contact time in 2nd ACF filter unit. Experimental results had revealed that the breakthrough of ACF reached at the time of 90 min for both 1st and 2nd ACF filter units during 5.5 hours duration. And the maximum adsorption capacity of zinc for single ACF filter was found to be 20 mg/cartridge or 0.42 mg of Zn (II) per mg of ACF. In case of dual ACF filter units, the highest % removal was found to be 94.34% at initial concentration of 90 mg/L whereas % removal was found to be 99.99% at initial concentration of 50 mg/L (in case of single/1st ACF filter unit). Similarly, Zn (II) % removal increased with the increase of flow rate of the feed solution. And the flow rate of 50 ml/min was found to be the optimum for the efficient removal of zinc at the initial zinc feed concentration of 50 mg/L. At this condition, the zinc % removal reached almost 93.38% from the 2nd ACF filter unit. In terms of adsorption isotherm study of the process, Langmuir–I isotherm model gave the best fit with the experimental data and R² value was found to be 0.9998, suggesting the monolayer homogeneous coverage of zinc on the ACF surface.

4. Conclusion

1) The removal efficiency (%) increased with increase of flow rate of feed solution but decreased with increase in initial concentration in the feed solution and operational time (contact time).
2) The Zn–ACF adsorption system follows the Langmuir–I isotherm model.
3) Adsorption using ACF as an adsorbent is a viable method for zinc removal from aqueous solution.

**References**

