Lewatit S100 in Drinking Water Treatment for Ammonia Removal

H. M. Abd El-Hady, A. Grünwald, K. Vlčková, J. Zeithammerová

Ammonium nitrogen is the most important form of nitrogen that can cause excessive algal growth and stimulate eutrophication in surface water. The purpose of this study is to investigate the possibility of removing ammonium from drinking water by means of an ion exchange process. Polymeric Lewatit S100 material (particle-size 0.3–1.2 mm) was used. The breakthrough capacity was determined by dynamic laboratory investigations and the concentration of regenerant solution (5 and 10 % NaCl) was investigated. The concentration of ammonium ion inputs in the tap water that we used were 10, 5 and 2 mg NH$_4^+$ l$^{-1}$ and down to levels below 0.5 mg NH$_4^+$ l$^{-1}$. The experimental results show that the breakthrough capacity was very small at ammonium concentration 2 mg NH$_4^+$ l$^{-1}$ compared to its breakthrough capacity at ammonium concentration 10 mg NH$_4^+$ l$^{-1}$. There was no difference between regeneration by 10 and 5 % NaCl. We conclude that the use of Lewatit S100 is an attractive and promising method for ammonium concentration greater than 5 mg NH$_4^+$ l$^{-1}$ and till 10 mg NH$_4^+$ l$^{-1}$.

Keywords: Lewatit S100, ion exchange, ammonia removal, drinking water.
System operation parameters

The first experiment was carried out to see the exhaustion performance of Lewatit S100 using distilled water spiked at 10 mg NH₄⁺ l⁻¹ concentration. Then we applied tap water containing Ca⁺² = 60 mg l⁻¹ and Mg⁺² = 12 mg l⁻¹. The concentrations of ammonium input were 10, 5 and 2 mg NH₄⁺ l⁻¹ as (NH₄Cl) and down to levels below 0.5 mg l⁻¹.

In the regeneration phase, we used 5.0% NaCl at a volumetric flow rate of 8.7 ml min⁻¹, which is equivalent to 10.5 bed volumes (BV) per hour and then 10% NaCl. After regeneration, the excess Cl⁻ was removed from the Lewatit S100 by distilled water. This washing was repeated until visual tests with AgNO₃ revealed zero chloride.

3 Results and discussion

Breakthrough capacity

Within the scope of this work, the results from the first experiment using distilled water indicated that the volume of water treated till breakthrough, defined as 0.5 mg l⁻¹ in NH₄⁺, was 2570 BV (128.5 l), and the breakthrough capacity as (NH₄Cl) was 1.356 mol l⁻¹ for NH₄⁺ = 10 mg l⁻¹.

Fig. 2: Results from column study

NH₄⁺, was 2570 BV (128.5 l), and the breakthrough capacity was 1.356 mol l⁻¹ for NH₄⁺ = 10 mg l⁻¹.

Fig. 2 shows that for tap water containing calcium and magnesium ions, the breakthrough capacity and the volume of water treated till NH₄⁺ breakthrough were 0.156, 0.085, 0.0317 mol l⁻¹ and 295 BV (14.75 l), 340 BV (17 l), 380 BV (19 l), respectively. These values indicate that tap water produces a lower breakthrough capacity than distilled water, due to the presence of other ions, especially ions with a polyvalent charge in water, such as Ca⁺² and Mg⁺².

Fig. 3 shows that, for tap water, the evaluation of practical capacity exchange is a function of the entering concentration of NH₄⁺. These results reveal that the breakthrough capacity is lower by approximately 0.55 and 0.2 times at NH₄⁺ = 5 and 2 mg l⁻¹, respectively, than the breakthrough capacity at NH₄⁺ = 10 mg l⁻¹. Thus, Lewatit S100 can remove ammonium ions very quickly with a higher breakthrough capacity at initial ammonia concentration of more than 5 mg l⁻¹.

Comparing the results summarized in Table 1, it can be seen that the calcium elimination from solution of 10 mg l⁻¹ NH₄⁺ was higher than the other solution of 5 mg l⁻¹ and 2 mg l⁻¹. Magnesium was elimination from all ammonium solution with the same rate.

Regeneration effects

The elution curves (Fig. 4) indicate no difference between regeneration by (10 and 5%) NaCl solution. Table 2 shows that 29 BV (1.45 l) of NaCl solution is sufficient for ammonium elution using Lewatit S100. These results reveal that Lewatit S100 is slightly more economical when using 5% NaCl for regeneration.

Table 1: Results of experiments

<table>
<thead>
<tr>
<th>Resins</th>
<th>NH₄⁺ = 10 mg l⁻¹</th>
<th>NH₄⁺ = 5 mg l⁻¹</th>
<th>NH₄⁺ = 2 mg l⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ca⁺² (mg l⁻¹)</td>
<td>Mg⁺² (mg l⁻¹)</td>
<td>Ca⁺² (mg l⁻¹)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mg⁺² (mg l⁻¹)</td>
</tr>
<tr>
<td>Lewatit</td>
<td>2.85</td>
<td>1.29</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>1.01</td>
<td>1.22</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Elution of ammonia

<table>
<thead>
<tr>
<th>NaCl = 5%</th>
<th>NaCl = 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume (ml)</td>
<td>NH₄⁺ (mg l⁻¹)</td>
</tr>
<tr>
<td>500</td>
<td>0.65</td>
</tr>
<tr>
<td>1000</td>
<td>0.211</td>
</tr>
<tr>
<td>1200</td>
<td>0.09</td>
</tr>
<tr>
<td>1450</td>
<td>0.029</td>
</tr>
</tbody>
</table>
4 Conclusions

The experimental results indicate that Lewatit S100 as a cation exchanger can remove ammonium ions very quickly. Higher breakthrough capacity was found at an initial ammonium ion concentration of more than 5 mg/l compared to 2 mg. The calcium elimination was lower at an ammonium ion concentration of 10 mg/l. No difference between regeneration by 10 and 5% NaCl was observed. We conclude that the use of Lewatit S100 is an attractive and promising method for ammonium concentration greater than 5 mg NH₄⁺ l⁻¹ and till 10 mg NH₄⁺ l⁻¹.

References


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