Computer Simulation of HA Influence on Copper Bioavailability to the Fish Gills

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Abstract: Copper speciation in the gill microenvironment of neon terris (Paracheirodon innesi) and the influence of humic acid and pH on copper bioavailability were investigated using exposure experiment and chemical equilibrium calculation. It was found that the copper speciation was changed because of the influence of the humic acid. With the existence of humic acid, the dominant species of copper in the bulk solution was humic acid complexed copper. However, humic acid complexed copper along with mucus complexed copper dominated the fish gill microenvironment. Consequently, the bioavailable copper species both in the bulk solution and in the fish gill microenvironment were significantly reduced by humic acid. The result of the modeling also indicated that the influence of pH was more significant under alkaline condition.

Keywords: fish; gills; copper; speciation; bioavailability; equilibrium modeling
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Paracheirodon innesi) pH, alkalinity and gill mucus content (Table 1).

![Figure 1: Copper speciation in the bulk solution (without humic acid) as a function of pH](image)

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Table 1 Simulative calculated pH, alkalinity and gill mucus content.

<table>
<thead>
<tr>
<th>pH</th>
<th>pKₐ</th>
<th>CuCO₃</th>
<th>CuOH⁺</th>
<th>Cu(OH)₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.00</td>
<td>0.64</td>
<td>6.2 μmol/mg</td>
<td>0.57</td>
<td>0.59</td>
</tr>
<tr>
<td>6.50</td>
<td>0.64</td>
<td>6.2 μmol/mg</td>
<td>0.57</td>
<td>0.59</td>
</tr>
<tr>
<td>7.00</td>
<td>0.64</td>
<td>6.2 μmol/mg</td>
<td>0.57</td>
<td>0.59</td>
</tr>
<tr>
<td>7.50</td>
<td>0.64</td>
<td>6.2 μmol/mg</td>
<td>0.57</td>
<td>0.59</td>
</tr>
<tr>
<td>8.00</td>
<td>0.64</td>
<td>6.2 μmol/mg</td>
<td>0.57</td>
<td>0.59</td>
</tr>
<tr>
<td>8.50</td>
<td>0.64</td>
<td>6.2 μmol/mg</td>
<td>0.57</td>
<td>0.59</td>
</tr>
<tr>
<td>9.00</td>
<td>0.64</td>
<td>6.2 μmol/mg</td>
<td>0.57</td>
<td>0.59</td>
</tr>
</tbody>
</table>
2.2

Fig. 2 Copper speciation in the fish gill microenvironment (without humic acid) as a function of pH

Fig. 3 Copper speciation in the bulk solution at various concentrations of humic acid
Fig. 4  Copper speciation in the fish gill microenvironment at various copper concentrations

Fig. 5  Difference in copper speciation in the fish gill microenvironment with or without humic acid

Fig. 6  Difference in humic acid complexed copper between the fish gill microenvironment and the bulk solution at various pH
Fig. 7  Difference in copper bioavailability between the fish gill micro-environment and the bulk solution as a function of humic acid and pH

3.0 7 7.0  pH

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