Chlorine dioxide disinfection by-products in the Nová Bystrica-Čadca-Žilina Long Distance Water Supply System

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Current practice related to disinfection follows two approaches:

2. Maintenance of residual concentration of disinfectant and effort to find methods for achievement of acceptable concentrations of disinfection by-products.

3. Search for new methods of sound management of distribution system without maintaining the residual concentration of disinfectant.
Concentrations of chlorine dioxide in the Nová Bystrica-Čadca-Žilina Long Distance Water Supply System

- at the beginning of Long Distance water supply system were ranged from 0.20 to 0.50 mg/l.
- at the Krásno upon Kysuca water reservoir were determined in range from 0.02 up to 0.25 mg/l.
- the concentrations lower than 0.02 mg/l were observed at the Považský Chlmec water reservoir
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In some countries it is required or recommended to maintain residual concentration of disinfectant in order to meet limits of microbiological parameters, minimize bio-film formation, prevent from secondary contamination in distribution system and indication, whether contamination occurs as results of disinfectant concentration reduction.
Monitoring of water disinfection by-products in the Nová Bystrica-Čadca-Žilina Long Distance Water Supply System

During these samplings the following water disinfection by-products have been determined:

- **trihalogenmethanes**: chloroform (CHCl₃); bromodichloromethane (CHBrCl₂); dibromochloromethane (CHBr₂Cl); bromoform (CHBr₃)
- **dichlorophenols**: 2,3-DCP; 2,4-DCP; 2,5-DCP; 2,6-DCP
- **trichlorophenols**: 2,4,5-TCP; 2,4,6-TCP
- **perchlorophenol**: PCP
- **benzene and its derivates**: benzene, chlorobenzene, ethylbenzene, 1,2-DCB; 1,3-DCB; 1,4-DCB; toluene, xylenes
- **another substances**: 2,4-D acid (2,4-dichlorophenoxyacetic acid); 1,1,2-trichloroethene (TCE); 1,2-dichloroethane; tetrachloromethane (CCl₄); 1,1,2,2-tetrachloroethene (PCE)
- **humic substances**
Results from monitoring of water disinfection by-products and other organic substances in the Nová Bystrica-Čadca-Žilina Long Distance Water Supply System

<table>
<thead>
<tr>
<th>Water disinfection by-product</th>
<th>Maximum concentration</th>
<th>Limit Decree no.151/2004</th>
<th>Percentage limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorobenzene</td>
<td>6,6 µg/l</td>
<td>10 µg/l (MH)</td>
<td>66 %</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethen</td>
<td>1,0 µg/l</td>
<td>10 µg/l (NMH)</td>
<td>10 %</td>
</tr>
<tr>
<td>Xylenes</td>
<td>1,4 µg/l</td>
<td>100 µg/l (MH)</td>
<td>1,4 %</td>
</tr>
<tr>
<td>Benzene</td>
<td>&lt; 0,5 µg/l</td>
<td>1,0 µg/l (MHRR)</td>
<td>&lt; 50 %</td>
</tr>
<tr>
<td>Toluene</td>
<td>1,3 µg/l</td>
<td>50 µg/l (MH)</td>
<td>2,5 %</td>
</tr>
<tr>
<td>Chloroform</td>
<td>3,0 µg/l</td>
<td>40 µg/l (MH)</td>
<td>8 %</td>
</tr>
<tr>
<td>Humic substances</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw water: 1,2-3,4 mg/l</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treated water: 0,6-1,0 mg/l</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Aliphatic carboxyl acids:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexadecanoic acid</td>
<td>&lt; 0,50 µg/l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Octadecanoic acid</td>
<td>&lt; 0,40 µg/l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other carboxyl acids</td>
<td>&lt; 0,10 µg/l</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chlorites concentrations in the Nová Bystrica-Čadca-Žilina Long Distance Water Supply System

Course of chlorine dioxide and chlorite concentrations in the N.Bystrica – Krásno - P. Chlmec LDWSS
Chlorites concentrations in the Nová Bystrica-Čadca-Žilina Long Distance Water Supply System

Course of chlorine dioxide and chlorite concentrations in the N. Bystrica – Krásno - Čadca LDWSS

![Graph showing the course of chlorine dioxide (ClO2) and chlorite concentrations in the N. Bystrica – Krásno - Čadca LDWSS system. The graph plots concentration [mg/l] against delay time [hour].]
Conclusion

The results show that from the above substances only the following were determined over the detection limit: chlorobenzene, 1,1,2,2-tetrachloroethen, xylenes, toluene, chloroform, humic substances, chlorites, hexadecanoic and octadecanoic acids. The highest concentration was determined for chlorobenzene (6,6 µg/l that represents 66 % of limit under the Decree no. 151/2004 Coll.), chloroform (1,4 µg/l, 1,4 %), toluene (1,3 µg/l, 2,5 %) and 1,1,2,2-tetrachloroethen (1,0 µg/l, 10%).
Conclusion

Aliphatic carboxyl acids reached the concentrations lower than 0,50 µg/l. The maximum concentrations of chlorites (NMH 0,20 mg/l) ranged from 0,30 to 0,35 mg/l were detected at sites where the chloride dioxide concentration is very low.
Conclusion

Referring to own consumption of chlorine dioxide and course of its decomposition reactions in LDWSS it was recommended for providers to use chlorine dioxide dosages in concentrations of 0,25 – 0,27 mg/l at most and simultaneously to monitor microbiological and biological water quality, especially at stretches, where distributed water is disinfected only by chlorites.