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Microcystin-associated disinfection by-products: The real and non-negligible risk to drinking water subject to chlorination

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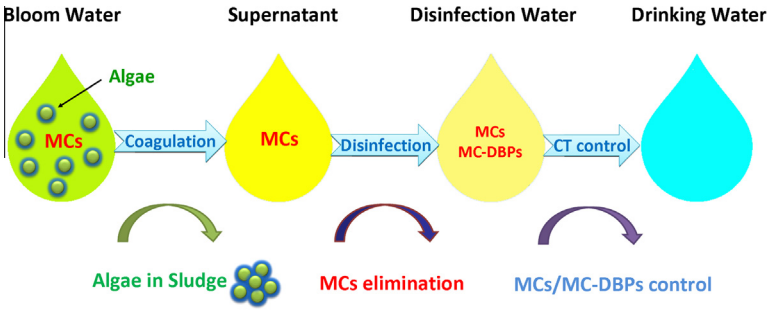
HIGHLIGHTS

- Chlorination was an effective treatment option for removing dissolved MCs.
- The elimination of water sample toxicity was clearly lagging behind MCs.
- Partial residual toxicity of water samples was attributed to MC-DBPs.
- The integral toxicity of MCs and MC-DBPs was a reliable control index.
- The toxicity of MCs and MC-DBPs could be effectively regulated by CT values.

GRAPHICAL ABSTRACT



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ABSTRACT

Chlorination of microcystin (MC) contaminated water is of concern due to the potential formation of undesired MC-associated disinfection by-products (MC-DBPs) in the treated water. To control the risk of MCs and MC-DBPs in chlorinated drinking water, the chlorination of MC contaminated water, the residual toxicity of water samples, and the potential risk of primary MC-DBPs were evaluated. Subject to chlorination, MCLR (the two variable amino acids at position 2 and 4 of MC are Leucine-L and Argnine-R) and MCRR (the two variable amino acids at position 2 and 4 of MC both are Argnine-R) were quickly transformed into various MC-DBPs and the toxicity of water samples on protein phosphatase 1 (PP1) gradually decreased with chlorination contact time. Though MC-DBPs had lower biological toxicity than the original MCLR and MCRR, their real and non-negligible risk to drinking water also deserved further attention even though MCLR and MCRR were completely degraded. Comparing to MCLR concentration, the integrated toxicity of water samples (MCs and MC-DBPs) was a more suitable control index for MCs contaminated water. As the toxicity of water samples was closely related to CT values (the cumulative value of residual concentration of chlorine multiplied by contact time), the risk of MCs and MC-DBPs

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could be effectively controlled by providing adequate contact time when chlorine concentration was restricted. This study offers a comprehensive evaluation of the hazard of MCs and MC-DBPs, and provides a valid technique support for the control of their potential risk to drinking water.

1. Introduction

Drinking water disinfection has been widely used to eliminate waterborne diseases and is important for public health [1,2]. However, disinfectants can react with natural or synthetic organic matters to produce a variety of toxic disinfection by-products (DBPs) [3,4]. Shortly after the first DBPs were identified in the mid-1970s, the association between DBPs and increased risk of diseases was verified [5,6]. To balance waterborne diseases and DBP formation, utilities should evaluate the chemical characteristics of disinfectants and DBP precursors. Compared to the disinfectants, the organic constituents of raw water were complex and varied with upstream pollution, climate, and other factors [7]. Taking the wide distribution of organic matters into account, disinfection may produce a myriad of DBPs that vary from one water source to another [8]. To evaluate the effect of chlorination, several regular DBPs were selected as the control indexes and relative guidelines in feedwater were established [9,10].

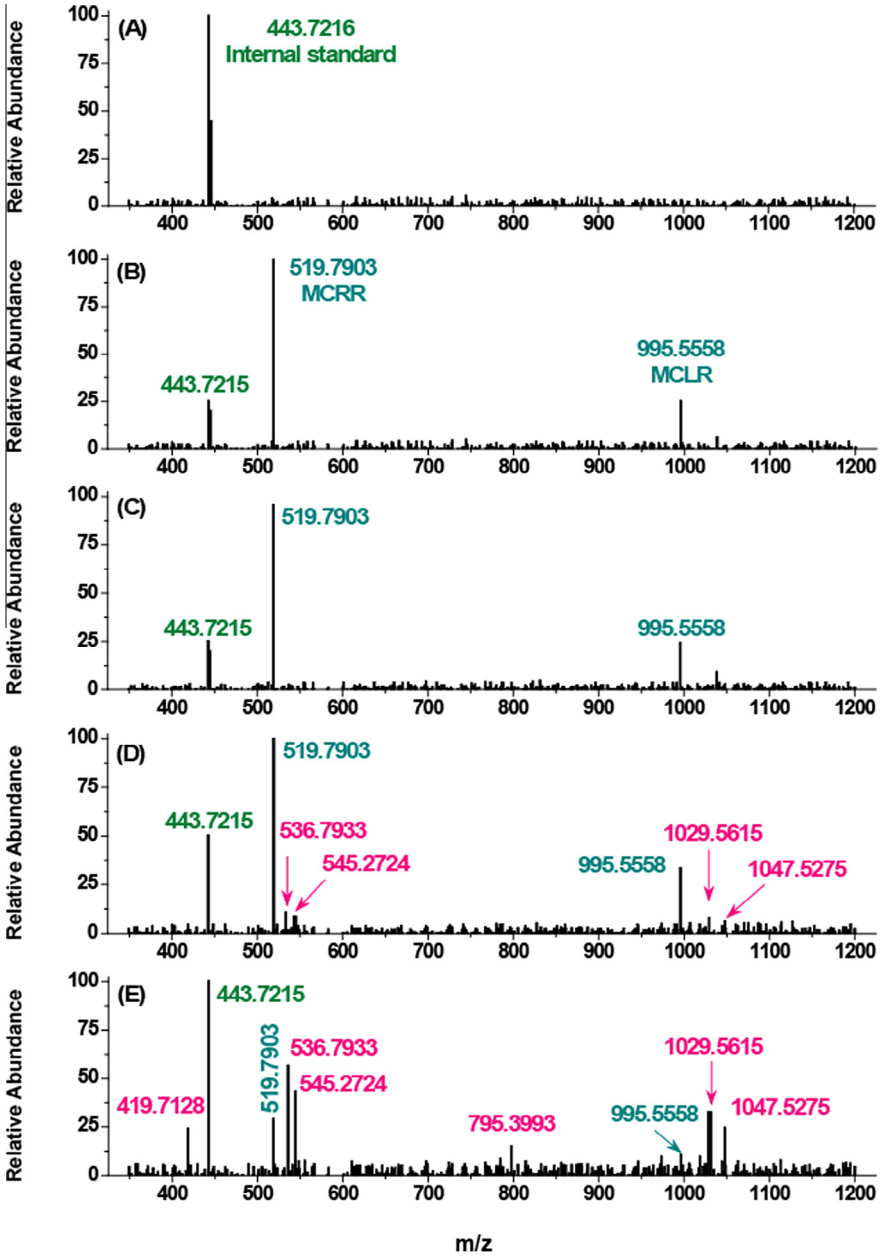

Fig. 1. Mass spectra of raw water (A), spiked water (B), supernatant (C), and disinfection samples exposed to 2 mg/L chlorine for 5 min (D) and 20 min (E) (with their separate maximum abundances fixed at 100%).