Determination of Disinfection By-Product Formation and their Minimisation in Potable Water Treatment Plants in South East Queensland

N. Knight\textsuperscript{1}, M. Farré\textsuperscript{2}, G. Shaw\textsuperscript{1}
\textsuperscript{1}Australian Rivers Institute, Griffith University, Southport, Queensland, Australia
\textsuperscript{2}Advanced Wastewater Management Centre, University of Queensland, St. Lucia, Queensland, Australia

Summary

The current project investigates which disinfection practices are most appropriate in providing South East Queensland’s potable water, in terms of disinfection by-product minimisation. The research presented here examines the factors affecting N-nitrosodimethylamine (NDMA) formation as a consequence of drinking water disinfection practices using chlorination and chloramination. We investigate the NDMA formation potential of South East Queensland source waters, as well as actual NDMA concentrations occurring at South East Queensland water treatment plants and at the point of supply.

Keywords
NDMA; disinfection; nitrosamines.

Background

Disinfection of drinking water by chlorination was introduced in Australia in the early 1900’s, and subsequent incidences of water-born disease being transmitted via drinking water have been rare (Block 2001). Today, drinking water treatment plants in South East Queensland (SEQ) continue to use chlorination (including pre-filter chlorination in some instances) or a mixture of chlorination and chloramination in order to maintain effective disinfection. However, disinfection by either of these processes can create potentially harmful chemical by-products as a result of the reaction between the disinfectant and existing organic matter in the source water (Sadiq et al 2004). These disinfection by-products are primarily trihalomethanes (THMs) such as chloroform, and nitrosamines such as N-nitrosodimethylamine (NDMA). While chloramination generally leads to lower concentrations of THMs than chlorination, it has the potential to produce elevated levels of NDMA and other nitrosamines. NDMA is known to be a potent carcinogen, however, there is also some evidence of the carcinogenicity of the THMs, as well as possible deleterious reproductive effects (Bove et al 2004, Richardson et al 2007). With the development of the SEQ water grid, booster chlorination or chloramination may be required to ensure disinfectant residuals in the distribution system, which may lead to increased disinfection by-product formation.

This project investigates the factors affecting NDMA formation as a consequence of chloramination, taking into account the source water used (in particular its organic component) and the processes employed during water treatment and distribution. As such, we are assessing a number of different SEQ source waters in order to determine the potential for NDMA formation, while also analysing existing potable water supplies to determine NDMA concentrations at the point of supply. This knowledge will be used to make informed decisions about which disinfection processes should be used in both proposed and existing water treatment plants in SEQ, to allow consistently low NDMA concentrations to be achieved.

Upon conducting a short-term monitoring program for NDMA in chloraminated Brisbane waters, we found water sourced from both Mt Crosby and North Pine water treatment plants (WTPs) generally had very low NDMA concentrations (<5 ng/L), both before and after disinfection at the plant, as well as at the point of supply. However, one potable water sample point was found to have a high NDMA concentration of up to 17 ng/L (a guideline value would be expected to be 10 ng/L) which reached a maximum at approximately the fourth litre fraction. The results implied formation in the distribution line in this case, however the cause and extent of this is as yet unknown. NDMA formation potential experiments were also conducted on water sourced from Mt Crosby and North Pine WPTs, and it was found that pre-chlorination at the filtration stage of treatment led to a lower NDMA formation potential, with water that had been through pre-chlorination having an average NDMA formation potential of 7 ng/L and unchlorinated water having an NDMA formation potential averaging 11 ng/L (Figure 1). Although pre-chlorination at the filters may be useful in lowering NDMA formation potential, this process may lead to higher THM concentrations.
Figure 1. Variation in NDMA formation potential of water from West Bank Mt Crosby filters over five weeks. Pre-chlorinated filters have consistently lower NDMA formation potential than unchlorinated filters.

References