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ORIGINAL PAPER

Assessing the effect of initial vapor-phase concentrations on inhalation risks of disinfection-by-products (DBP) in multi-use shower facilities

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Abstract Inhalation during showering activities is a major pathway for exposure to volatile disinfection-by-products (DBPs). Disinfection-by-products such as trihalomethanes (THMs) and haloacetic acids (HAAs) have been shown to significantly increase cancer risks and can also pose other health hazards. In multi-family residences and common-shower facilities located in dormitories and gymnasiums, the time-lag between showers is likely to be short and the exposure to vapor-phase DBPs may be significantly increased due to residual concentrations from earlier showering activities. Current models do not consider the impacts of the initial vapor-phase concentration on health risks to be significant. The hypothesis that non-zero initial DBP vapor-phase concentrations lead to higher exposure and health risks was evaluated here using data from the City of Corpus Christi, TX at two levels of input parameter uncertainty. The inhalation risks and hazards were found to be over 1.5 times greater for subsequent showers compared to the initial shower of the day. For non-zero initial air concentrations and triangular distribution of input parameters, the model was found to be most sensitive to the initial air concentrations, highlighting the impact of initial conditions on cumulative daily intake (CDI) and subsequently on cancer risks and hazard indices. Increasing the time-gap between showers and improving ventilation are viable solutions to contend with the increased risk. It is recommended that the effects of initial air concentrations be incorporated in future risk assessments focusing on multi-family residences in older and poor neighborhoods where single shower dwellings are more common.

Keywords Trihalomethanes · Haloacetic acids · Initial concentrations · Monte carlo · Environmental justice · Indoor air quality · Modeling

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Introduction

Disinfection by chlorine compounds reduces biological risks associated with exposure to pathogens in water but unfortunately increases chemical risks due to the formation of hazardous by-products. Disinfection-by-products (DBPs) are formed when chlorine based compounds react with natural organic matter (NOM) in water. Several disinfection-by-products, particularly trihalomethanes (THMs) are shown to enhance the risk of bladder, colon, and rectal cancers (e.g., Morris et al. 1992; Kuo et al. 1998; Thiriat et al. 2009; Pardakhti et al. 2011) and cause birth-defects (Bove et al. 1995; Reif et al. 1996) and adverse pregnancy outcomes (Aschengrau et al. 1993; Singer et al. 2003). Given these deleterious effects there is a growing concern on evaluating the exposure of humans through intake routes and quantifying associated health risks (e.g., Wang et al. 2007; Hamidin et al. 2008; Chowdhury and Champagne 2009; Legay et al. 2011; Basu et al. 2010). Exposure to disinfection-by-products occurs with all activities involving chlorinated water and include drinking, cooking, laundry, dishwashing, bathing, and showering. Most trihalomethanes (THM) and haloacetic acids (HAA) are volatile and, therefore, the inhalation pathway is a dominant route of exposure. The volatility of these compounds increases with