Disinfection by-products in the atmosphere of indoor swimming pools

Marko Hyttinen // *Joonas Ruokolainen*// *Pertti Pasanen*

University of Eastern Finland, Department of Environmental and Biological Sciences, Kuopio

Introduction

- Disinfection chemicals are needed in swimming pools to control formation and spreading of pathogenic micro-organisms between swimmers
- Disinfection by-products (DBP) are formed when disinfectants, such as chlorine or sodium hypochlorite (NaOCl), are added to water that contains organic or inorganic impurities. Inhalation and dermal absorption are the main exposure routes of the DBPs in swimming halls
- All the DBPs may cause irritative symptoms in respiratory tract and eyes

Materials and methods

- Indoor air quality monitoring was done in 32 Finnish swimming pool and spa areas during the opening hours

Volatile organic compounds (VOCs)

- Tenax TA + Chromosorb 106 adsorbent combination. Sampling was conducted in dressing rooms, bathrooms, and pool areas
- Analyzed with TD-GC-MS
- Quantitation with toluene and chloroform equivalents

Trichloramines (TCA)

- Na_2CO_3 + As_2O_3 impregnated filter were used in the sampling. Analysis was made according to the SFS-EN ISO 10304-1 standard. Samples were collected at bathrooms, and pool areas. 30 facilities.

Results

- Total concentrations of VOCs were slightly higher in bathrooms compared to pool areas (Table 1)
- DBPs found in bathroom and pool area are presented in table 1. The most commonly found DBPs were trichloramine and chloroform
- Numerous nitrogen and halogenated DBPs were found in pool area, however their concentrations were relatively low. In addition, many unreliably identified "DBPs" were detected
- Some commonly found VOCs in different sampling sites are listed below:
  - Dressing room: Alpha-Pinene, Decamethyl-cyclopentasiloxane (D5), Decanal, Eucalyptol, Nonanal, 2-ethyl-1-hexanol. Small amounts of chloroform was detected from some dressing rooms (mean 4±7 µg/m^3).
  - Bathroom: Alpha-pinene, Chloroform, D5, Decanal, Eucalyptol, Hexadecane, Nonanal, Toluene
  - Pool area: Benzoic acid, Chloroform, D5, Decanal, Eucalyptol, Menthol, Methyl isobutyl ketone

Table 1. Mean TVOC, chloroform and TCA concentrations at the measuring sites. Concentrations are presented in µg/m^3 (maximum concentration, number of swimming pools/spas where the compound was detected in)

Compound	Bathroom	Pool
TVOC (mean, max)	125±120 (max: 500, n: 29)	85±55 (max 310, n: 32)
TCA	22±24 (max 100, n: 30)	115±86 (max: 330, n: 30)
Chloroform (TA+CS106)	22±25 (max 86, n: 27)	60±49 (max 269, n: 31)
Benzonitrile	1±1 (max: 1, n: 2)	1±1 (max: 3, n: 20)
Benzoyl bromide	N.D.	0 (n: 1)
Benzoyl chloride	N.D.	1 (n: 1)
Bromodichloromethane	1±1 (max: 2, n: 10)	1±1 (max: 6, n: 31)
Chloroacetaldehyde	1 (n: 1)	0±1 (max: 1, n: 2)
Chlorohexane	0 (n: 1)	0±1 (max: 0, n: 3)
Dibromochloromethane	0 (n: 1)	0±0 (max: 1, n: 4)
Dichloroacetonitrile	1±1 (max: 2, n: 8)	1±1 (max: 6, n: 31)
Haloesters*	0±0 (max: 1, n: 8)	0±0 (max: 1, n: 11)
Isobutyronitrile	0±0 (max: 1, n: 4)	1±1 (max: 4, n: 25)
Methylbutanenitrile	1±0 (max: 1, n: 6)	2±1 (max: 6, n: 25)
Trichloroacetone	0±0 (max: 0, n: 4)	0±0 (max: 1, n: 15)
Trichloronitromethane	0±0 (max: 0, n: 3)	1±1 (max: 3, n: 8)

*Identification uncertain

Discussion

- TCA and chloroform were the main DBPs found in the air of swimming pools. In some pools TCA concentration exceeded 300 µg/m^3, that has been suggested as the new occupational exposure limit value (OEL). Current OEL for TCA is 500 µg/m^3
- Many nitrogen-containing DBPs were also found and they were likely formed from nitrogen-containing pre-cursors such as urine, sweat and skin cells. Also, personal care products react readily with disinfection chemicals
- Pool user's hygiene is important way to reduce formation of DBPs (so take shower before swimming)

Figure 1. Swimming pool "AaltoAlvari" Jyväskylä Finland

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