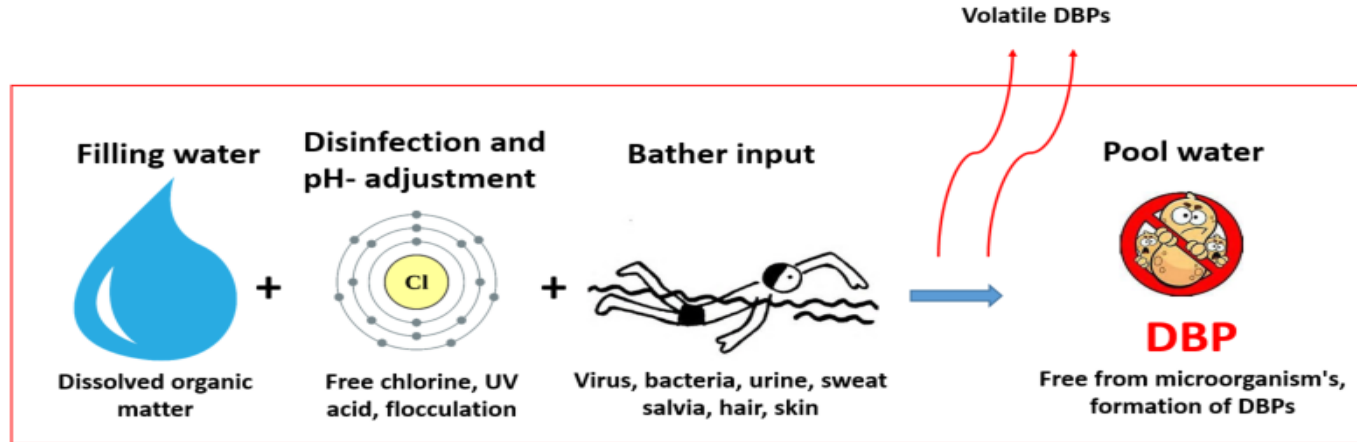




AIR QUALITY IN A NORWEGIAN INDOOR SWIMMING POOL FACILITY: A CASE STUDY

Indoor Air 2018, July 26th
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FORMATION OF DISINFECTION BY- PRODUCTS (DBPs)



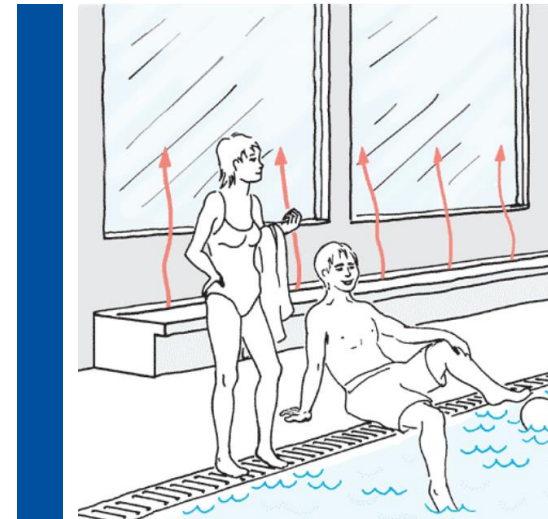
- More than 600 DBPs
- Trihalomethanes (THM)- of the most important groups
 - Chloroform- CHCl_3 *
 - Bromodichloromethane- BDCM *
 - Dibromochloromethane- DBCM
 - Bromoform- CHBr_3
- Very to extremely volatile
- Easily penetrates the skin
- Exposure through dermal contact and inhalation

BACKGROUND

No limit values for THMs in air/water of Norwegian pool facilities exist

Norwegian guidelines

- 4-7 ACH for conventional swimming facilities
- 8-10 ACH for rooms with hot water pools
- Maximum air velocity of 0.15 m/s above the water surface to reduce evaporation and save energy
- Typically 30 % of the supplied air volume is fresh air from outside



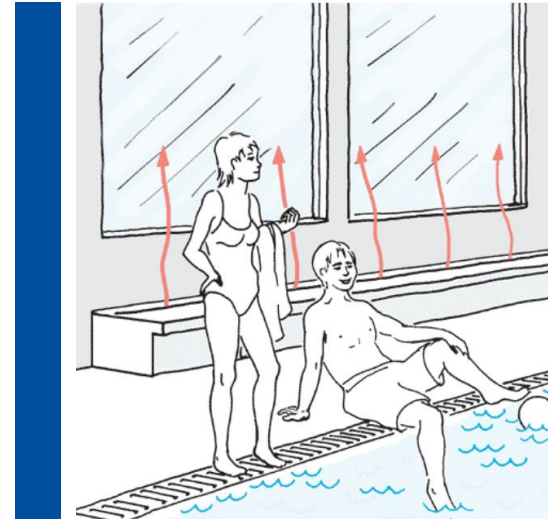
BACKGROUND

From previous studies:

Limited number of air samples from limited sampling locations

Long-term exposure to tTHM:

- Reproductive outcome and bladder cancer
- Cancer risk found to be unacceptably high (above 10^{-5})





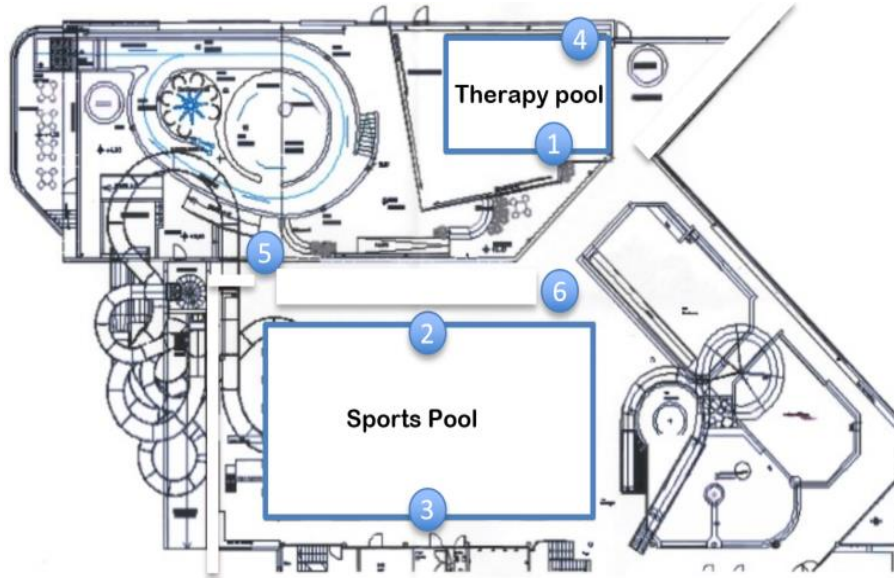
AIM

Document the distribution of THMs 0.05 m and 0.6 m above water surface

From various locations in the poolroom, both in the morning and afternoon

Analyze the relation between the level of THM above the water surface; ACH, fresh air supply, RH and sampling location

THE STUDY OBJECT



Disinfection

- On-site production of NaOCl
- UV-treatment

ACH:

- 3.0- 3.7

ACH_{freshair}

- 0.4 - 3.7

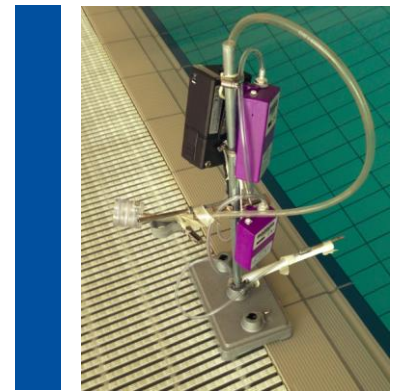
Visitors per year: 120 000

METHOD

Sampling during morning and in the afternoon

Air samples;

- 0.05 m and 0.60 m above water surface, six locations
- through sorbent tubes containing Tenax TA at 40 ml/min for 20 min



Free chlorine, combined chlorine, pH, air- and water temperature, number of bathers, relative humidity, ACH and fresh air supply were registered

THMs were determined by Unity thermal desorption coupled to a GC/MSD

Based on US EPA Method TO-17 and ISO 16017

RESULTS

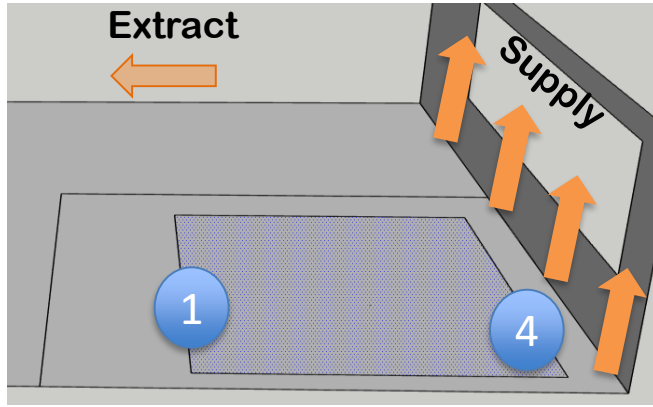
CHBrCl₂ was detected on 53 of 93 samples

CHCl₃ was always detected (96.4 - 100% of tTHM)

Calculated using $\ln(\text{tTHM})$

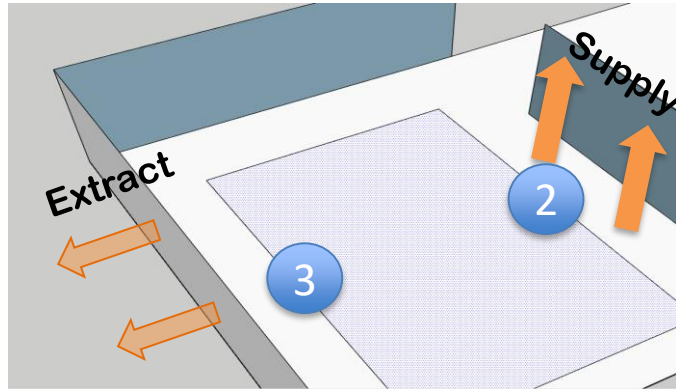
- **Within sampling location variability: 0.07**
- **Between sampling location variability: 0.04**

RESULTS



Sampling location 1 vs. 4 (Therapy pool)

- Mean tTHM and RH always slightly higher at location 4 vs. location 1
- Non statistically significantly different



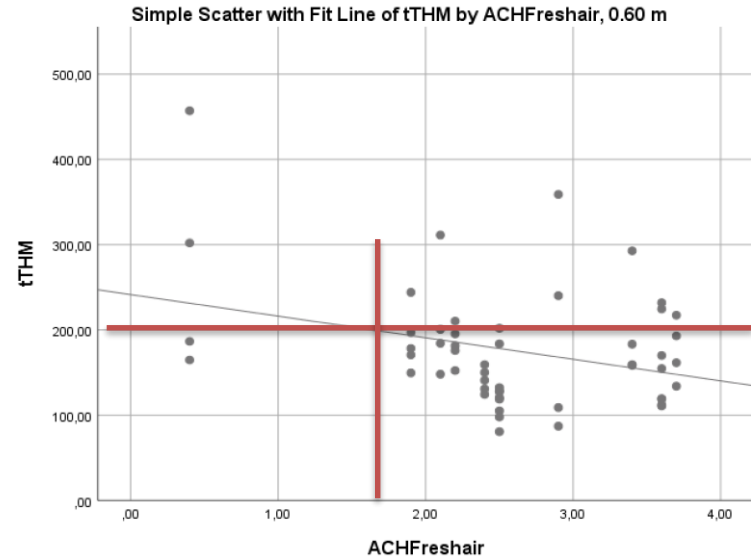
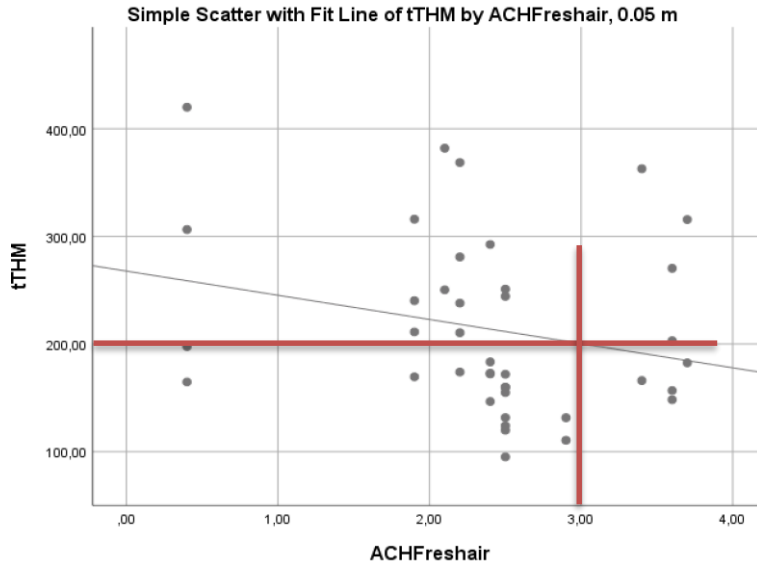
Sampling location 2 vs. 3 (Sports pool)

- 37% higher levels of tTHM obtained at 0.60 m
- 88% higher levels of tTHM obtained at 0.05 m
- Statistically significantly different

RESULTS

The German Federal Environmental Agency: $\text{CHCl}_3 \leq 200 \mu\text{g}/\text{m}^3$ (VDI 2089)

→ 33 % of the samples above this value



Average measured $\text{ACH}_{\text{freshair}}$ was 2.5

Average required $\text{ACH}_{\text{freshair}}$ is 3.0 (0.05 m) and 1.7 (0.60 m)

DISCUSSION

The vapour densities of CHCl_3 and CHCl_2Br are greater than air

- Tend to stay near the surface of the pool
- Low air velocities not suitable to dilute the contamination
- ACH , $\text{ACH}_{\text{freshair}}$ and RH significantly correlated with measured tTHM in the air

Minimum requirement of fresh air needed to ensure proper air quality in the breathing zone of the swimmers

Between sampling location variability → Heterogenic contamination within the poolroom → new ventilation strategy needed?

CONCLUSIONS

The concentration of THM, RH, and T_{air} varies within the poolroom and highlights the importance of taking air samples from multiple stationary sampling locations

Higher concentrations of tTHM were obtained above the water surface

The air system is more dynamic than the water system

- Strong correlation between the tTHM, ACH, and $\text{ACH}_{\text{freshair}}$ → important to monitor air- and water quality

More research on ventilation concepts in swimming halls in general, and flow patterns close to the water surfaces in particular should be prioritized



THANKS FOR LISTENING!

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