

Swiss Centre for Occupational and Environmental Health

# Clean air against pathogens: the role of air flow and ventilation

Michael Riediker

# What I will show you



Aerosols go with the flow.

Aerosols are hard to model.

Solution: Combine model with observations & measurements.

# Release: fine + larger aerosols



**SCOFH** 

# Two modes of respiratory aerosols SCOEH



# Physics of gases and aerosols

# SCOEH



### Gases move and diffuse.

#### Aerosols go with the flow.

	Air molecules	0.1 μm Aerosol	1 μm Aerosol	10 μm Aerosol	100 µm Aerosol
Sedimentation speed	0	0.00087 mm/sec	0.035 mm/sec	3.1 mm/sec	261 mm/sec
stopping distance @ 10 m/s initial speed	2.5*10⁻ <sup>6</sup> mm	0.0088 mm	0.035 mm	2.3 mm	130 mm
Brownian diffusion in 10 sec	28 mm	0.12 mm	0.023 mm	0.007 mm	0.002 mm

Calculated for air at 20°C, 1013 hPa und spherical, solid aerosols of 1g/cm<sup>3</sup> Dichte. Mean diameter of air molecules: 0.00037 μm. Source: Aerosol Measurement. Principles, Techniques and Application. 3<sup>rd</sup> ed. Kulkarni, Baron and Willeke. John Wiley & Sons Inc. 2011.

## Fog to understand indoor aerosol flow



## Fog for modelling transfer & exposure

Large and complex rooms



REHVA 14th HVAC World Congr

ridam. The Net

Nr. 8





**SCOEH** 

#### CLIMA 2022 22nd - 25th May Rott

#### Aerosol transmission in rotary wheel heat exchangers.

Heinrich Huber +, Thomas Richter +, Florian Brzezinski +, Michael Riediker +

e of Building Technology and Energy, Lucerne University of Applied Sciences and Arts, H Judier@Bulu.ch. Borian brazzinski@bulu.ch. b Hoval Aktiengesellschaft, Vaduz, Lichtenstein, thomas richter@hoval.com SCOEH: Swiss Centre for Occupational and Environmental Health, Winterthur, Switzerland, ichael.riedlizer@lalumpi.athu.ch.

> niting air transfer be nents (HRCs) are used as standard in new ventilation systems. Rota erv efficient, but have a higher exhaust air transfer ratio (EATR) o ery, but also carries a rick of to r gas. In 16 me rsults are available, furthe

ate of the art and is even req ired in th (1). Rotary heat excl economic widely used. A disadvantage of

RHE is that due to the physical principle and the insfer ratio (EATR) can occur than with other mmon heat recovery categories such as plate heat e.g. in the R ever, RHEs are not generally eq



### Ventilation systems



# Cloud in a large empty room





# Thermal plume





Humans are heat sources and create upwards air streams

# Thermal plume + floor air supply



# Pockets of stagnant air



#### In collaboration with team of Heinrich Huber, HSLU

# Flow often not as expected



In collaboration with team of Heinrich Huber, HSLU

# Quantify non-mixed situation?

A: There is mixing, just modified efficiency

**B:** No real mixing taking place



## Situation A: Modified efficiency in mixed room

![](_page_14_Picture_1.jpeg)

- Virus-emitting person(s) as source
- Reduction by ventilation and in-room (virus t<sub>1/2</sub> + measures)

![](_page_14_Figure_4.jpeg)

seco-Tool for estimating the viral dose in a well-mixed room: https://scoeh.ch/de/tools Based on (1) Riediker, M. et. al., Swiss Med Wkly. 2022;152:w30133 (2) Riediker, M., Monn, C. Aerosol Air Qual. Res. 2021;21, 200531. (3) Riediker M, Tsai D-H. JAMA Netw Open 2020;3:e2013807. (4) Nicas M. JOEH 2016;13:519–28. (5) 1 Keil C, Zhao Y. JOEH 2017;14:793–800.

![](_page_15_Figure_1.jpeg)

![](_page_15_Picture_2.jpeg)

# Take-home message

Aerosols are not gases. They go with the flow.

Perfect mixing is rare in large rooms.

There is a way to model scenarios in complex situations: Visualize, collect data and integrate it in your model!

# SCOEH

# Thank you!

- The international scenario modelling team: Leonardo Briceno-Ayala, Gaku Ichihara, Daniele Albani, Deyan Poffet, Dai-Hua Tsai, Samuel Iff, Christian Monn
- The ventilation research team of Prof. Heinrich Huber, HSLU
- Health and Safety expert Felix Wolfart, Schauspielhaus Zürich

michael.riediker@scoeh.ch