Suitable ventilation in schools – mechanical or natural?

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1. Background/Introduction

Bundesinstitut
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Raumforschung
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und Raumordnung

Bundesministerium
für Umwelt, Naturschutz,
Bau und Reaktorsicherheit

- Future demands on holistic optimized buildings -> "Leitfaden Nachhaltiges Bauen" (Guideline for sustainable building) + "Bewertungssystem Nachhaltiges Bauen (BNB)" (evaluation system for sustainable buildings), since 2013 obligating for federal buildings

- Research project "Grundlagen- und Konzeptentwicklung für die Analyse von praxisgerechten Lüftungskonzepten" (basics and concept development for analysis of practice-oriented ventilation systems)

- Project aim: development of recommendations for different ventilation concepts and constellation of rooms as well as an evaluation approach for the BNB for rooms with high number of persons on the basis of CO_2 concentration

1. Background/Introduction

- Evaluation criterion - 3.1.3 Innenraumlufthygiene" (Indoor air hygiene): especially pollutants of indoor air due to pollutants from building products and **carbon dioxide emissions** of the persons using the room

Ventilation system	Quality level (QN)	Carbon dioxide concentration in the classroom* Average value of the time interval (teaching unit of 45 Min.)	Outdoor air flow rates in (m³/h)/person	Evaluation points	Catergory according to DIN EN 13779
Mechanical ventilation	2	≤ 800ppm	≥ 54	50	IDA 1
	1	≤ 1000ppm	≥ 36	25	IDA 2
	0	≤ 1400ppm	< 36	Certification impossible	IDA 3
Window ventilation	2	≤ 800ppm	≥ 54	45	IDA 1
	1	≤ 1000ppm	≥ 36	20	IDA 2
	0	≤ 1400ppm	≥ 21,6 und < 36 With carbon dioxide light	0	IDA 3
	-	> 1400ppm	≥ 21,6 und < 36 Without carbon dioxide light or < 21,6	Certification impossible	IDA 4

* Including concentration of atmospheric carbon dioxide (400ppm)

- Different boundary conditions for verification for window ventilation and hybrid ventilation (such as temperature difference 7K, 5min. brief and intensive airing by opening windows, average wind velocity 3m/s,…)
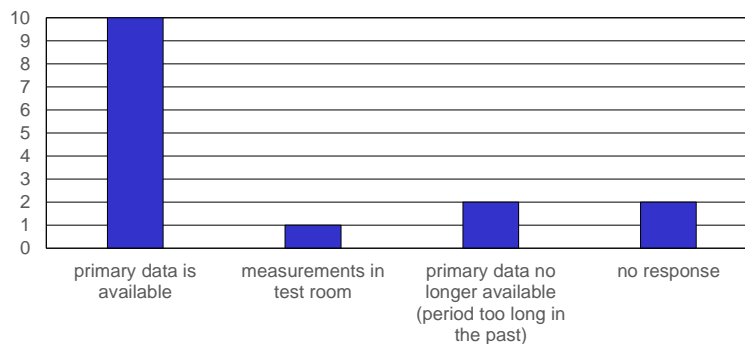
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2. Overview of studies

Basic conditions for the requested studies:

- Mostly studies in the German-speaking area (all with same clime)
- CO_2-measurement in schools

Contacting with project managers of 15 selected studies with a request form

Results of contacting

2. Overview of studies

Basic conditions for the requested studies:

- Studies in the German-speaking area (same clime)
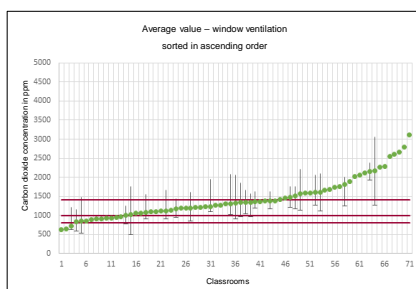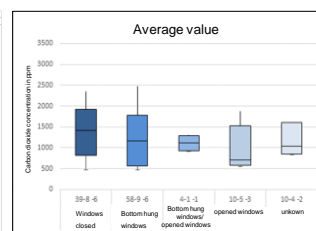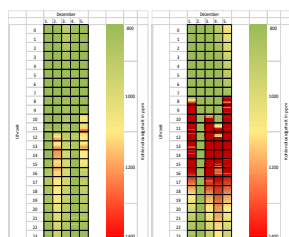- CO_2-measurement in schools

Contacting with project managers of 15 selected studies with a request form

- More than 27 schools

- More than 111 classrooms

- More than 1394 teaching units

→ What are similar parameters?

→ What are ideal-typical parameters?

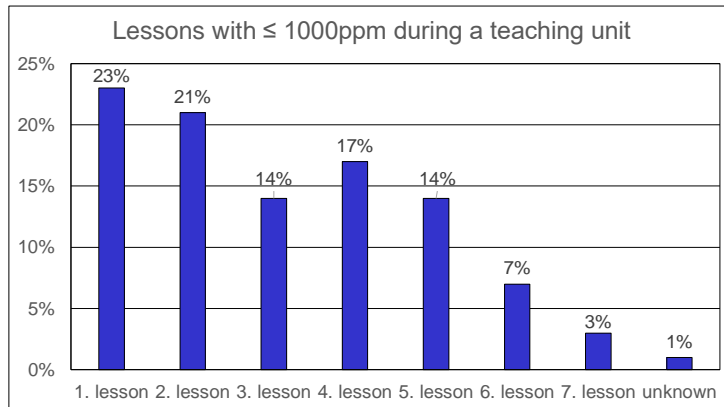# 3. Method of analysis

Possible methods of analysis are:

- Carpet plots
- Box plots
- Scatter plots
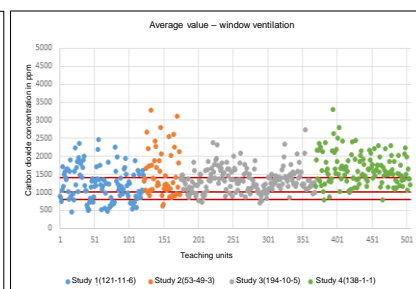
4. Intermediate results

Window ventilation:

- ≤ 1000ppm during a teaching unit in only approx. 17% of the considered lessons (total 506 lessons)

- > 1400ppm during a teaching unit in approx. 43% of the considered lessons

Lessons with ≤ 1000ppm during a teaching unit

Lesson	Percentage
1. lesson	23%
2. lesson	21%
3. lesson	14%
4. lesson	17%
5. lesson	14%
6. lesson	7%
7. lesson	3%
unknown	1%

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4. Intermediate results

Mechanical ventilation:

- ≤ 1000ppm during a teaching unit in approx. 40% of the considered lessons (total 513 lessons)

- > 1400ppm during a teaching unit only in approx. 9% of the considered lessons

- Outdoor air flow rates according to DIN EN 13779 IDA 2 or IDA 3 designed → 1000 or 1400 ppm "mäßige Raumluftqualität" (moderate indoor air quality)

- CO_2-controlled systems often with switch point at >1250ppm

- Ventilation systems are designed to support bigger air volume flows, but this ventilation levels are not used by reason of high acoustic emissions at these rotational speeds

Hybrid ventilation:

- Mechanical basic ventilation to minimize increase of carbon dioxide

- brief and intensive airing by opening windows by means of centrally controlled motor driven window casements (to avoid inefficiently continuous ventilation by users)

- Planned value in considered studies for 1h mean value time series is to high (< 1400ppm)

5. Recommendations for further studies

- Further studies (minimum requirements for information/values to be documented → "Idealstudie" (ideal study) such as in-situ measurements of carbon dioxide, in connection with concentration performance, log of ventilation (number of opened windows, window position (opened, bottom hung, closed,…), duration,…), number of pupils, grade level, room area, room volume, information about ventilation system (for example: air volume flow,…))

- Derivation of recommendations from statistical outdoor temperatures

- Specification of ventilation interventions in real classrooms or test rooms (taking into consideration disturbances) → What carbon dioxide concentration will be built up over time?

- Evaluation of ventilation systems based on the number of lessons with overstepping carbon dioxide concentrations in ppmh

- Studies about working low-tech ventilation concepts in classrooms (optimum ratio between window ventilation and mechanical ventilation as hybrid ventilation?)

Thank you for your attention!